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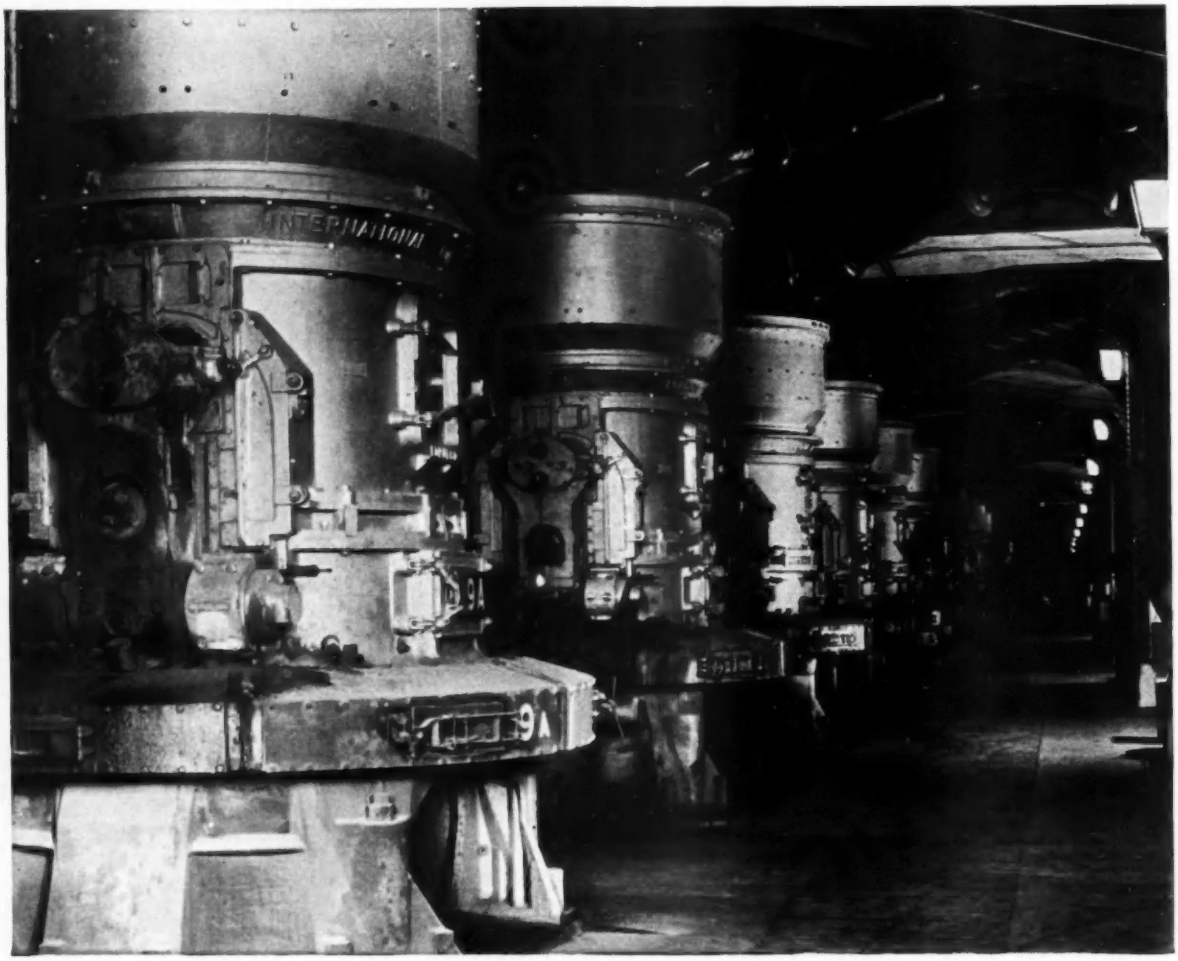

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Engineering and BOILER HOUSE REVIEW

THE OLDEST ESTABLISHED STEAM ENGINEERING PUBLICATION

MAY 1961

VOLUME 76. No. 5

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The Editor will be glad to receive and consider original contributions, correspondence, etc., of a suitable nature for publication. Stamped and addressed envelopes should be enclosed for the return of any matter considered unsuitable

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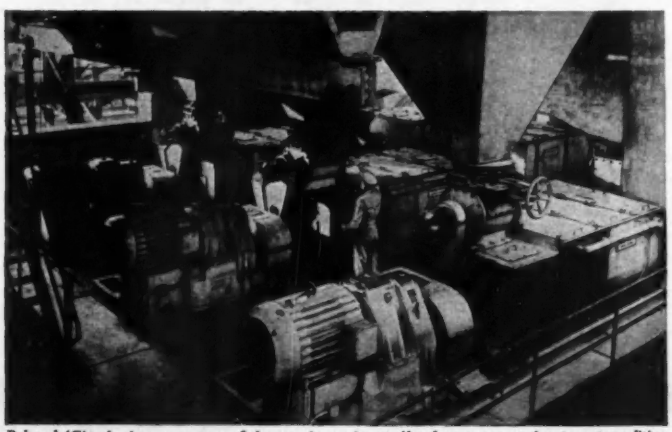

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THE INSTITUTE OF FUEL

THE Annual Luncheon of the Institute of Fuel was held at the Connaught Rooms, London, on Wednesday, April 19th. The President of the Institute, Dr. W. A. Macfarlane, C.B.E., presided, and the assembly totalled more than 700 members and guests, the latter including representatives from the Ministry of Power, the National Coal Board, the Electricity Council, the Central Electricity Generating Board and the presidents and vice-presidents of various other engineering institutions and associations. The toast of "The Institution" was proposed by Sir Julian Pode, J.P. (managing director, the Steel Company of Wales Limited; and member of the Grand Council of the Federation of British Industries). Sir Julian, in his speech, said the Institute has steadily grown in influence over the past twenty years because it covers every aspect of the fuel problem—supply, technology, utilisation, etc. It has become the national forum for engineers practising in any and every branch of the industry. Traditionally, the people of this country are extravagant in their use of fuel, because for centuries they have enjoyed the most ample and cheapest supply of coal of any country in Europe.

The First World War, and still more the Second, showed that this extravagance rested on an insecure foundation and that fuel supplies which, until recently had meant coal almost entirely, were in jeopardy. We were, therefore, forced by war into the practice of fuel economy, and this led to a much wider and more important movement—that of fuel efficiency. Only an actual shortage could have persuaded most industrialists that they had to become efficient in fuel utilisation, because in so many industries the percentage of the cost of production represented by fuel is so small. The heavy industries were not in that category and the steel industry has been a major contributor to developments in fuel efficiency. Considerable trouble and expense to improve techniques, and the consequent achievement have been great. For instance, in 1920 over three tons of coal or its equivalent were required to produce a ton of finished steel—now it is half that amount. Continuing, Sir Julian pointed out that during the war, the engineers of the then Ministry of Fuel had the task of dictating to industry the amount and quality of fuel to be used, and of improving boiler house practice. Their achievements in the sphere of combustion were spectacular, but they got little thanks, and one of the aftermaths of the war was the creation of the National Industrial Fuel Efficiency Service to take over from the Ministry the work of training boiler house personnel and of educating industrialists in the need to conserve energy. The sponsors of N.I.F.E.S. were the National Coal Board, the Electricity Council, the Gas Council and the South of Scotland Electricity Board. The seven-year record of N.I.F.E.S. is impressive. Assistance has been provided to more than 6,000 factories, non-industrial premises and local authorities, and it is estimated that savings of the order of £10 million have been achieved. We have now reached a point at which there is a glut of coal, and fuel oil has become highly competitive in price; a situation which the Government now proposes to remedy. One cannot help sympathising with the Coal Board for, with an extractive industry, it is difficult to adjust output quickly whether upwards or downwards. The sudden down-turn in demand for coal in 1957 forced the Board to maintain a volume of output greater than they could sell and to stock the surplus coal while plans were being devised for reducing the scale of production. The social problems involved in contraction were exceedingly serious. Ought we now to return to the era of fuel wastage ? The answer is, of course, NO ! The National Coal Board, far from reducing its educational activities in the sphere of fuel economy, is extending them. This is plain commonsense.

The reply to the toast of the Institute was by the President (Dr. Macfarlane), who said that they were all greatly indebted to Sir Julian Pode for sparing the time from his busy programme to join them that day, and to propose the toast of the Institute. What Sir Julian has said brings into sharp relief the contract between the problems which will engage the Institute of Fuel during the 'sixties, and those with which we have been struggling since the war. In the 'fifties, the pattern seemed fixed. It was firmly forecast that the demand for energy would go on increasing, steadily and rapidly. And there was a single problem in front of us—how to spread the limited supplies of fuel to meet that rising demand. Today, we see that neither of these basic assumptions holds good any longer. Clearly we must take a much more sophisticated view of how the demand for energy will change. It is no longer prudent to assume that demand will go on and on, up and up—even in an expanding economy.

Dr. Macfarlane then referred to the other assumption that once seemed so certain—how quickly have we moved from conditions of fuel shortage to abundance; the result that, instead of scraping the bottom of all the barrels to meet requirements, there are dozens of different ways in which the fuel supplies of the 'sixties may be made up. It is the expressed view of some people that some time late in the 'sixties, it will become economic to generate electricity from nuclear energy. Dr. Macfarlane said that he favoured a radical solution and believed that we must harness our resources properly in order to ensure throughout the 'sixties that the major part of Britain's energy requirements is met, as it can be met, by British coal. To bring this about we must harness our resources properly. This not only calls for the N.C.B. to continue its drive to produce coal more efficiently and cheaply, it also means that far greater efforts must be devoted to coal science and coal technology. Dr. Macfarlane said he was left in little doubt that other people may have other views about the fuel supplies of the future. But, of course, it is the great privilege of the Institute of Fuel that it provides the forum where different views and new advances can be reported, discussed and tested. He felt confident that it will continue to fill this role in the years to come.

Points and Pointers

POWER STATION SITES IN YORKSHIRE The Central Electricity Generating Board states that two of the sites investigated in the West Riding of Yorkshire have been found suitable for large coal-fired power stations. One of these is an extension of the Board's existing site at Ferrybridge, between Knottingley and Castleford, where two stations with an aggregate plant capacity of 470-MW are now in operation. The other is at Eggborough, about four miles east of Knottingley. Both sites are on the eastern fringe of the Yorkshire coalfield, which is second only to the adjoining East Midlands coalfield as a producer of coal for electricity generation. The Yorkshire coalfield possesses large reserves, and the National Coal Board expects in the future to supply substantially increased quantities of the small coals that power station boiler furnaces can burn efficiently. The Ferrybridge site already has a rail connection and, being on the navigable part of the River Aire, it can also receive coal in barges from those collieries accessible to water transport. The Eggborough site can be rail-connected by a short spur off the Wakefield/Knottingley/Goole railway line. Each site is considered suitable for a station of about 2,000-MW installed generating capacity and burning some five million tons of coal a year. Both are on the River Aire, which is the only adequate source of cooling-tower make-up water supply in this part of the coalfield. Early construction of both stations is necessary to meet the rapidly-increasing demand for electricity, and the Board are applying to the Minister of Power and the West Riding County Council for the necessary statutory consents. If authorised, the stations will incorporate the large highly-efficient boiler and turbine units that have become such a feature of the Board's current development programmes. A third site, on the River Aire, at Gowdall, to the east of Eggborough, is believed to be potentially suitable for a station to meet later growth of demand, subject to further study of cooling-water supply problems. Further investigations are also required into the problems of siting a station on the River Don, additional to the 1,100-MW Thorpe Marsh station now under construction about four miles N.N.E. of Doncaster.

INDIA CALLS IN U.K. FUEL EFFICIENCY EXPERT The formal launching of India's third five-year plan, which started on April 1st, 1961, and in connection with which it is estimated that £7,500 million will be spent in private and public investment over the five-year period, adds interest to an announcement on April 6th by the National Industrial Fuel Efficiency Service that a member of their staff, Mr. C. A. J. Plummer, M.Sc., A.R.I.C., M.Inst.F., has left for Delhi to carry out a six-months' programme of investigation into fuel consumption at selected Indian factories. The tour, arranged under The Colombo Plan, and with the Commonwealth Relations Office, was preceded by three or four days' discussion at The Ministry of Commerce and Industry in Delhi. Thereafter, Mr. Plummer moved on to Calcutta for two months' work with the Indian Coal Control Organisation, where he will be joined later in the month by another N.I.F.E.S. engineer, Mr. B. R. Addicott, who will assist in the investigations. Background to the visit, is an application made last year by The Government of India for an expert in fuel economy to advise selected industries on problems of fuel and steam conservation. In India, coal is still the chief fuel burned for power generation and for energy production in general, so that with growing industrial expansion, it is necessary to economise in its use. It is, of course, true that large programmes for stepping up the output of coal in India are under way, but the full benefit of these will not be obtained if too great a proportion of increased transport facilities is devoted to carrying the extra tonnage, as besides the haulage of coal they have to cater for the transport of an ever-expanding amount of other raw materials and finished goods. The more efficient use of fuel will make coal stocks last longer, and will relieve pressure on transport.

NEW NUCLEAR ENGINEERING COMPANY FORMED Three well-known industrial concerns, Imperial Chemical Industries Limited (Metals Division), Rolls-Royce Limited and The Rio Tinto Co. Ltd., have jointly formed a new company to operate in the field of civil nuclear engineering in collaboration with the atomic power consortia. The new company is to be called Nuclear Developments Limited and the United Kingdom Atomic Energy Authority has been kept fully-informed of its formation. Each of the participants has, in addition to wide technical resources and skills, experience which will, it is claimed, be appropriate to the future role of the new company in nuclear engineering. Rio Tinto mines, extracts and processes uranium on a large scale. Rolls-Royce has been engaged in the nuclear field for the past eight years and has a specific interest in marine nuclear propulsion. I.C.I. Metals Division has made several notable contributions to technological progress in nuclear engineering over the last 20 years and has exceptional facilities for the manufacture of nuclear metals and reactor components. With these combined resources at its disposal, Nuclear Developments Limited will be in an unrivalled position to meet demands, as and when they can be met by private industry, for fuel preparation and fuel element manufacture for civil reactors.

BEAMA GUIDE TO ARC WELDING ELECTRODES The British Electrical and Allied Manufacturers' Association have published a new and completely-revised 100-page edition of their "Guide to Arc Welding Electrodes," which is designed to assist the user in the choice of suitable electrodes for each purpose. Outstanding technical advances in engineering construction have been made possible by welding techniques, notably in the construction of nuclear power plant and associated equipment, and the greater specialisation that is

taking place is increasing the demand for information on electrodes. The guide was first published in 1944, and this is the sixth edition of this publication, giving in a convenient form, classified lists of British electrodes, and a key to American and British Electrode Standards. To assist consumers in choosing the correct electrode for a particular application, there is included in the guide a brief description of the British Classification of Electrodes published by the British Standards Institution as B.S. 1719 : 1951. In this issue, a more complete description of the American method of classifying electrodes is given, and the equivalent American code numbers are shown in all the classified lists. For those interested in electrodes for welding non-ferrous metals, cast-iron, corrosion-resistant and other steels, a section is included which gives information on special electrodes and lists of the special electrodes available. Copies of the guide (price 5s.) are available from The British Electrical and Allied Manufacturers' Association, 36, Kingsway, London, W.C.2.

START OF CONSTRUCTION AT SIZEWELL NUCLEAR POWER STATION

Work began on April 4th on the construction of the atomic power station at Sizewell, Suffolk, which is being built for the Central Electricity Generating Board by the English Electric-Babcock and Wilcox-Taylor Woodrow atomic power group. On completion in 1966, the station will have a capacity of 580-MW. In all, excavation for its construction will amount to over 500,000 cu. yd., but before detailed excavation of the foundations can begin, it is necessary to move and level approximately 300,000 cu. yd. of sand. Bulk excavation methods are being used to move this quantity within five weeks of the starting date. While this is in hand, progress is being made on a system of access roads round the site and the erection of the many temporary buildings required. It is expected that by the beginning of July, detailed excavation of the reactor foundations will be well advanced, and the majority of the temporary works required initially on site will be in operation. An important feature of the civil engineering work will be the construction of the cooling-water intake, 1,800 ft. from the shore, through which sea-water will be drawn at the rate of over 27,000,000 gal. an hour, and after use, discharged at a point 500 ft. off-shore. Four tunnels of 10 ft. diameter have to be driven, under compressed-air, to positions below the intake or outfall. Shafts will then be raised through the sea bed to form intake and outfall, which will be finished from working platforms established above high-water level.

NATIONAL COAL BOARD SALES DRIVE

A press conference which was held recently under the chairmanship of the Rt. Hon. Alfred Robens, chairman of the National Coal Board, had as its object the launching of the most extensive sales campaign in the history of the coal industry. The reason for this sales drive is that the coal industry has been steadily losing business to the oil industry, and appreciates the fact that it must fight hard not only to develop new markets, but also to hold on to existing customers. Mr. Robens said that the nation has invested £900 million in the coal industry since vesting day, and is entitled to have the best results from that investment. With this in mind, the present aim is to develop the demand for coal to a level of 200 million tons per year, and to maintain this demand. The campaign has been directed initially to domestic fields, and in this connection credit terms are to be made available wherever the Board sells house-coal direct to the public. The Coal Board has put forward a specification covering a new domestic boiler, and this will be made by several leading manufacturers in the field to their own detailed designs. Although coal is not a consistent product naturally, the consumer requires consistency, which involves careful preparation of the coal. Over £70 million has already been spent on new or reconstructed coal-preparation plants and a further 50 plants costing £24 million are projected for the future. Nearly 120 million tons of coal are mechanically cleaned annually, and the additional plant will clean a further 34 million tons. Nearly three-quarters of the total output will, therefore, be cleaned. The Coal Board have also set up a technical advisory service, staffed by fuel technologists with wide experience in boiler-house practice. This service is available to advise on the best equipment for a particular job.

C.E.G.B. REORGANISATION

Alterations are being made in the regional structure of the Central Electricity Generating Board; the changes are being made gradually, and may be spread over two or three years. The present rather cumbersome designations of the Regions are being reduced to simpler form, and the names of the Divisions changed to some extent. The North West, Merseyside and North Wales Region will be styled North Western Region. The North Eastern and Yorkshire Region will become simply the North Eastern Region; the North Eastern Division will continue to be termed North Eastern Division, and the Yorkshire Division will be known as the Southern Division of that Region. The Midlands and East Midlands Region will now be the Midlands Region, and its two Divisions will be West Midlands (now Midlands) and East Midlands (as at present). The Eastern, London and South Eastern Region will be known as the South Eastern Region; the London Division will disappear, and the two other existing Divisions will be termed North Thames (now Eastern) and South Thames (now South Eastern). Their boundaries will be essentially coterminous with the Thames North and Thames South Grid Control areas. The Southern, South Western and South Wales Region will be called the South Western Region, and the existing Divisions—South Wales, South Western and Southern—will retain their present names. In all Regions, except the North Western, it is proposed to set up a Regional Transmission Construction Department under a regional electrical engineer, to deal with transmission construction work in the field. The Divisions will be concerned entirely with the operation and maintenance of the power stations and transmission lines in their areas. The officer in charge of each Division will be entitled "assistant regional director" and will be a member of the Regional Executive Committee. In each Region there will be a deputy regional director who will deputise for the director when necessary but will normally be the chief engineer of his Region.

Elland Power Station

ELLAND power station, in Yorkshire, was officially opened on April 28th by Mr. A. R. Cooper, M.Eng., M.I.E.E., M.Inst.F., Member for Operations and Personnel, Central Electricity Generating Board. This station, which was engineered by the Board's Northern Project Group, Pendlebury, Swinton, Manchester, has an installed generating capacity of 180-MW, the plant comprising three 60-MW turbo-alternator sets and three 550,000 lb./hr. unit boilers. The station is located in the valley of the River Calder, about one mile east of Elland railway station. On the south side of the site is the main Manchester to Wakefield railway line, and to the north is the River Calder itself. Approximately 65 acres of low-grade agricultural land, liable to flooding, was taken over for the site, and an access road was constructed from the site to join an existing road to Elland. The entire road has been widened and strengthened to enable some of the heavy loads required, to be brought onto the site during the construction period. Reception sidings connect with the main railway line for coal delivery purposes, and access by rail is also available to the main power station buildings, having been provided for the purpose of bringing in loads which were too large to pass under a railway bridge over the access road. Accommodation for six trains, each comprising fifty-five 16-ton capacity wagons, is provided in the sidings, which run parallel to, and to the north of the main line. In order to prevent flooding, the whole site has been built up to a height above the highest anticipated flood-water level of the Calder. Owing to the position of the station in a comparatively narrow valley, particular attention was paid to the relative siting of the cooling towers and the chimney in order to avoid any nuisance from down-draught; the chimney being built to a height of 400 ft., an exceptional height for a station of this size.

Work commenced on site during August, 1954, and erection of the steelwork was started in March, 1957. The first two turbo-alternator/boiler units were commissioned in June and September, 1959, and the third unit in February, 1961. To overcome the problems of building on a sub-soil consisting of gravel over clay, a box structure was used for the main foundations with specially-strengthened vertical sections to support the heavy plant, whilst the spaces left in the box between the vertical sections are used for cable runs. Above this "sub-basement" is the main basement-level, which is some 7 ft. below ground-level. From basement-level to operating-floor-level, the height is only 20 ft., which is remarkably small compared with most power stations, and this results in a considerable reduction in building costs. Steel framing, clad with brick to a height of 14 ft. above ground-level, and finished above this level in aluminium sheeting, has been used for the turbine-house structure. Housed in this building are the three turbo-alternators, arranged transversely to the length of the building. Dimensions of this section are 233 ft. long, 88 ft. wide and 60 ft. high to the underside of the roof trusses. An overhead-travelling crane of 102 tons capacity spans the turbine house, and this again operates at minimum height in order to save cost. Adjoining the turbine house, and to the south of it, is the boiler-house. This has an operating-floor level some 10 ft. above that of the turbine house, although the basement-level is the same for both buildings. Steel framing has again been used, but in this case the cladding is of corrugated protected steel sheeting. The boiler-house is 208 ft. long by 125 ft. wide, and the height to the underside of the roof at the highest point is 134 ft. Between the turbine and boiler houses is an annexe in which, at basement level, the boiler feed-pumps are installed. Combined turbo-alternator and boiler control rooms are also located in this annexe at the same level as the turbine house

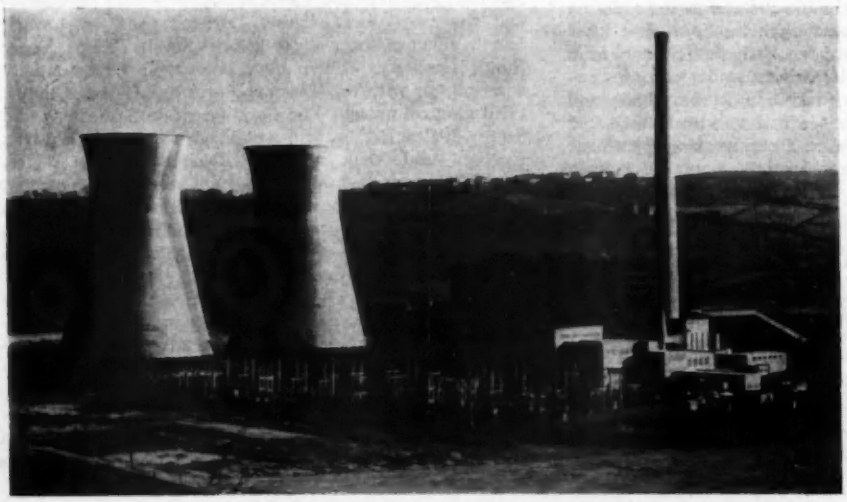


Fig. 1. Elland power station located about one mile from Elland, near the main Manchester-Wakefield railway line, has an installed generating capacity of 180-MW.

operating-floor, as are also the auxiliary switchgear panels. High-level deaeration is used, the deaerators being mounted in the annexe some 37 ft. above the turbine-house operating floor, whilst the water storage-tanks are mounted at boiler-house roof-level.

In the design of the boiler and turbine-houses, the object has been to produce a very compact arrangement, and to reduce building costs to a minimum, compatible with facilities for plant maintenance and architectural appearance. Offices and amenities for the operating staff are in a service group of buildings, west of the turbine and boiler-houses, on the Elland side of the station.

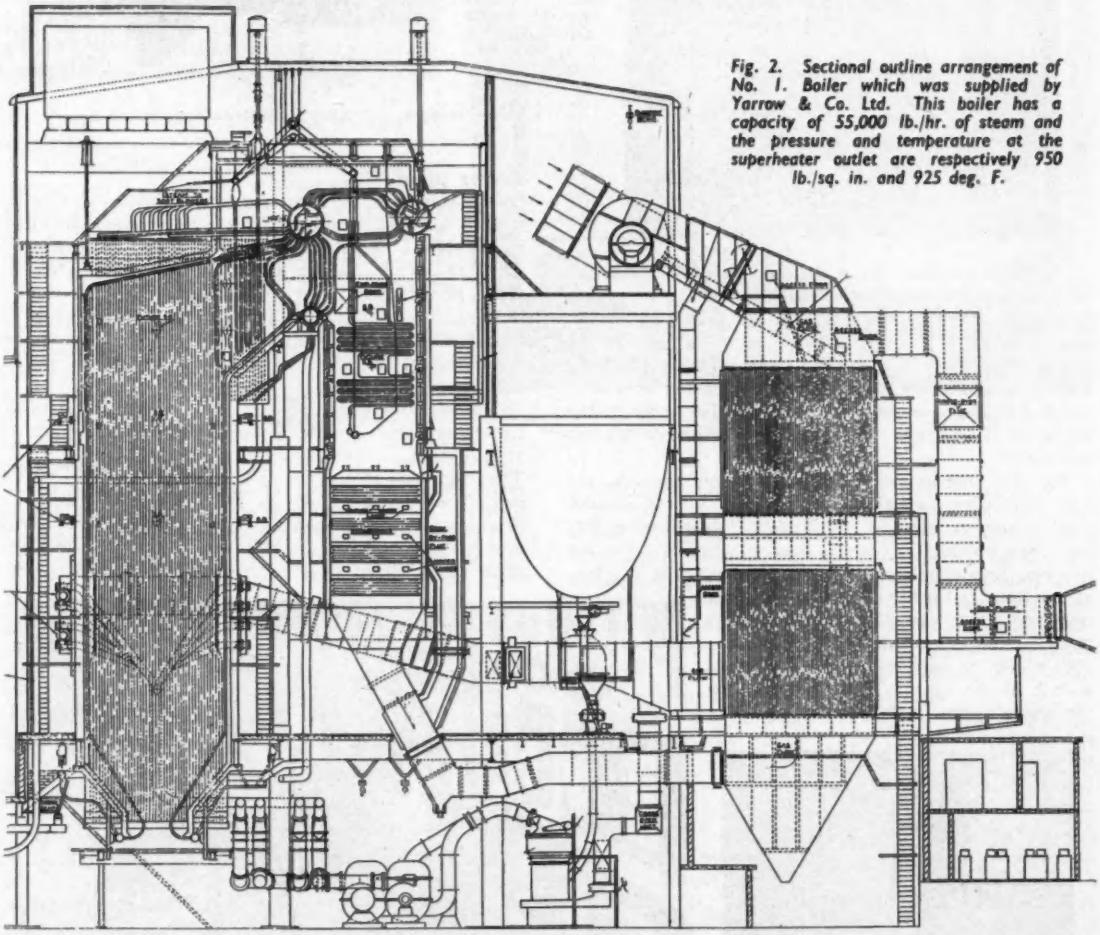


Fig. 2. Sectional outline arrangement of No. 1. Boiler which was supplied by Yarrow & Co. Ltd. This boiler has a capacity of 55,000 lb./hr. of steam and the pressure and temperature at the superheater outlet are respectively 950 lb./sq. in. and 925 deg. F.

This group contains the administrative offices, maintenance shops, stores, ablutions and changing rooms, laboratories, canteen and main control room, and consists of brick finished buildings.

Coal handling plant

Coal supplies are delivered from the South Yorkshire coal-field, mainly by rail, provision being made for road borne supplies as necessary, and approximately 16,000 tons/week comes into the station. Although the coal is deep-mined it is of low-grade quality, with an average calorific value varying between 9,200 to 10,000 B.Th.U./lb., and with ash and moisture contents up to 27 per cent. and 14 per cent. respectively. Average moisture, however, is about 8 per cent. The rail-borne coal is hauled by the power station's own diesel locomotives to a tippler-house where it is tipped on a 36 in. wide inclined conveyor belt, which takes it to a transfer tower where it can either be put into stock or taken on to the boiler coal-bunkers. The transfer tower contains screening and crushing plant to reduce the coal, if necessary, to a size suitable for the pulverising mills. A boom conveyor in the transfer tower discharges coal at a maximum rate of 75 tons per hour and this is distributed by bulldozer. Coal is also reclaimed from stock or can be taken in by road by another conveyor to the transfer tower. At present, the coal storage area is a temporary one, of 10,000 tons capacity, pending reclamation of ground which largely consists of worked-out gravel pits. Coal-handling on the storage area is being carried out by bulldozer. The final storage area will have a capacity of some 60,000 tons. The complete coal-handling and coal-recovery plant was supplied by Robert Dempster & Sons Ltd., Elland, Yorks. The conveyors, discharging

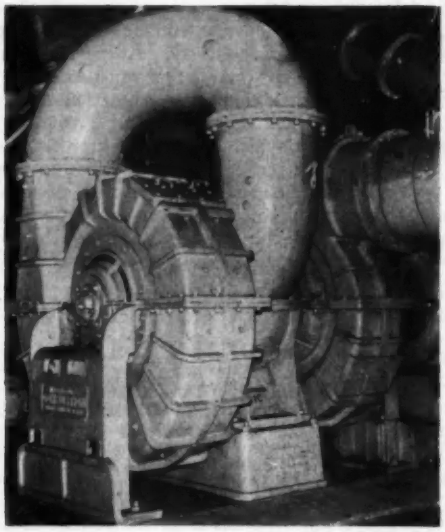


Fig. 3 (left). One of the four International Combustion Limited DE-49 variable-speed exhausters, associated with each Lopulco p.f. mill on No. 1 boiler.

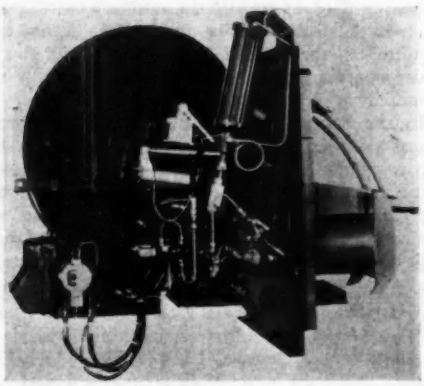


Fig. 5 (right). Type FF1 initiator supplied by Fuel Firing Limited for No. 1 boiler.

to the transfer tower from the tipplers and road-borne coal-hoppers, are fitted with magnetic head pulleys and over-band magnetic separators to remove any tramp-iron, and this is discharged by chute to the base of the tower. Provision is made for weighing the rail-borne coal by weighers integral with each tippler and by a belt-weigher in the conveyor from the transfer tower to the bunkers. Automatic coal-sampling equipment is also provided.

For the driving motors on the wagon tipplers, the coal conveyors, and the coal-crushers, Vulcan-Sinclair fluid couplings, supplied by Fluidrive Engineering Co. Ltd., are provided. For the wagon tipplers, there are two size-26 traction-type couplings transmitting 105 h.p. at 720 r.p.m.; for the conveyors there are two size-17.175 traction-type couplings rated to transmit 45 h.p. at 960 r.p.m., and a size-20 unit where the rating is 55 h.p. at 965 r.p.m. The drive unit for the coal-crusher includes a size-17.175 traction-type coupling, transmitting 30 h.p., at 960 r.p.m.

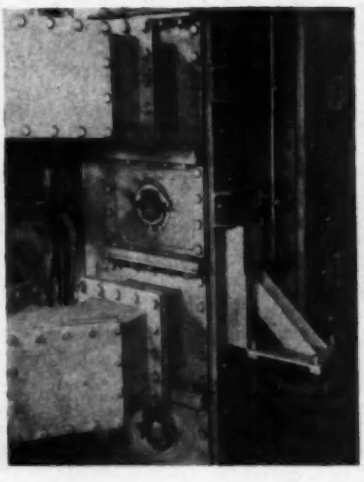


Fig. 4 (left). One of the p.f. tilting corner burners supplied by International Combustion Limited for No. 1 boiler. There is one burner in each corner of the furnace.

Boiler plant

The station is, perhaps, somewhat unusual in that the boilers have been supplied by two separate manufacturers, No. 1 boiler having been supplied by Yarrow & Co. Ltd., while Nos. 2 and 3 units were supplied by John Brown Land Boilers Limited. Each boiler is designed for an m.c.r. of 550,000 lb./hr. when supplied with feedwater at a temperature of 385 deg. F. Steam conditions at the superheater outlet are 950 lb./sq. in. and 925 deg. F.

The Yarrow boiler (No. 1) is a two-drum natural-circulation unit having a furnace heating surface of 10,440 sq. ft., and a furnace volume of 44,000 cu. ft. There are two steam drums each 5 ft. 0 in. dia., and a single feed-drum whose dia. is 2 ft. 6 in. The steam drums are connected together by steam and water cross-over tubes expanded direct into the drums, while the main steam drum is connected to the 2 ft. 6 in. dia.

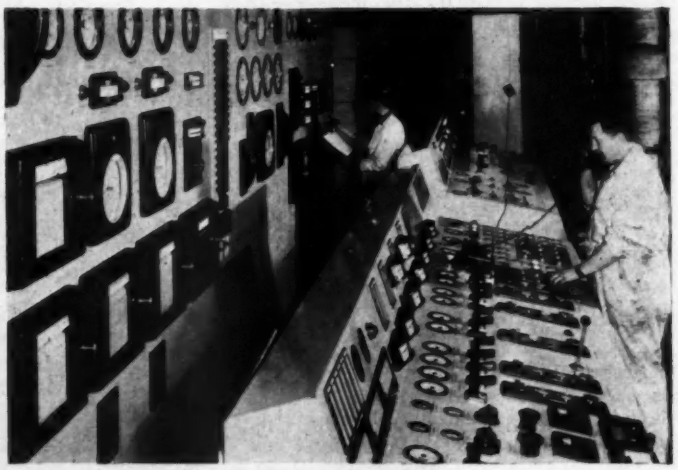


Fig. 6 (above). Unit control boards and instruments for two 60-MW boiler/turbine units.

feeder-drum by 95 downcomer tubes expanded direct into each drum. The 5 ft. 0 in. dia. feed drum is coupled to the feeder drum by a single row of 19 tubes expanded direct into each drum. The four lower-side, near and front-wall headers of the combustion chamber are fed by four downcomers welded direct to stubs on the feeder drum. The boiler is fitted with seven safety-valves, four of which are fitted to the feed drum, and three to the final superheater outlet header. A Hopkinson's external high- and low-water alarm is also provided. The combustion chamber is fully water-cooled in circuit with the boiler.

The economiser, supplied by E. Green & Son Ltd., is a "type 15" welded economiser, arranged for contraflow, viz., gas-flow downwards and water-flow upwards. The economiser is constructed in three tiers, and consists of 486 tubes, each 26 ft. 0 in. long, arranged 27 tubes wide by 18 high.

The airheater, which has a heating surface of 165,000 sq. ft., is of the Yarrow tubular-type, arranged for contraflow, viz., gas-flow upwards and air-flow downwards, the gas flowing inside the tubes and air flowing across the outside of them. The heater is divided into a top and bottom section, and is so arranged that the air-flow passes twice over each section. It is equipped with integral air by-pass ducts and air by-pass dampers arranged so that air can be by-passed as required. Provision is made so that hot air can be re-circulated from the air-heater air outlet ducts to the inlets of the forced-draught fans.

The boiler is equipped with three-element feed-water control equipment manufactured by James Gordon & Co. Ltd. Also provided is an electrically-driven Hayward Tyler pump arranged for circulating water from the feed drum to the economiser inlet. The boiler is also fitted with a Weir horizontal three-throw chemical injection pump which is capable of delivering 50 gal./hr. against a pressure of 1,100 lb./sq. in. and is suitable for hydraulically testing the boiler at a pressure of 1,860 lb./sq. in. Steam purity measurement equipment is installed to determine the purity of steam entering the superheater. This equipment consists of a Dionic water conductivity tube and an Evershed-Straub de-gassing condenser designed for a water throughput of 250 c.c./min.

The corner-fired furnace and the coal-pulverising equipment was designed and manufactured by International Combustion Limited. The pulverising plant consists of four Lopulco LM14 roller mills, three of which will be used to supply the boiler at its maximum rating, the fourth acting as a standby. The coal is supplied to each mill using variable-speed table feeders; each mill being designed to handle 22,130 lb./hr. of coal with a pulverised-fuel fineness of 96 per cent. minus 100 mesh B.S.S. The Lopulco mill is of the air-swept type, and hot air at 460 deg. F. is introduced into the mill so that drying and grinding are carried out simultaneously. Classification of the pulverised fuel is by a whizzer separator mounted in the mill outlet. Each Lopulco mill supplies, via one of the four DE49 variable-speed exhausters, a separate compartment in each of the corner burners. A burner is situated in each corner of the furnace and fires the fuel tangentially into the combustion chamber. As the burners are of the tilting type some measure of superheat control is afforded.

The driving motors for the exhausters, separators, and feeders were manufactured and supplied by Laurence, Scott & Electromotors Limited. The exhauster motors are of 180/55 b.h.p., and run at 1,470/960 r.p.m., the separator motors are of 9/2 b.h.p. and run at 2,200/880 r.p.m., while those driving the coal feeders are of 2/0.28 b.h.p. and run at 2,200/314 r.p.m. All these motors are of the N-S variable-speed type.

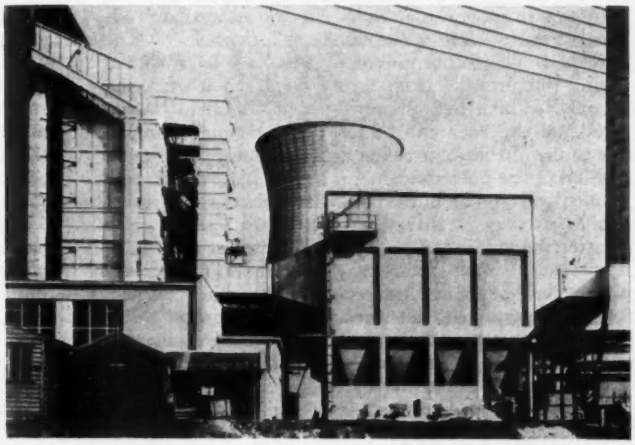


Fig. 7. A Holmes-Elex electrical precipitator, designed to handle 243,000 cu. ft./min. of gas, is installed before the I.D. fan on No. 1 boiler.

The connecting ducts from the hot air main and attemperating air ducts to the mills are each provided with a damper, which controls the quantity of hot and attemperating air being supplied to the mills and, consequently, the temperature of the p.f. air mixture leaving the mills. The dampers are fitted with Lockheed remote-control equipment supplied by Lockheed Precision Products Limited. The attemperating air connections are also used for mill cooling purposes.

The complete pumping and heating plant, which was supplied by Fuel Firing Limited, Woodley, Berks., is conventional, except, perhaps, that for ease of access the components are compactly installed on separate plinths, instead of the usual and somewhat inaccessible complete pumping and heating unit. There are three pumps, each of which is connected to a heater capable of handling 6,000 lb./hr. of fuel from 1,500 secs. Redwood No. 1 at 100 deg. F. The usual suction and discharge filters have been included, while all pumps are capable of being connected to operate in conjunction with any heater. The oil-supply pipework is arranged in the usual manner to ensure that oil, at the correct viscosity, is available at the initiators at all times. In order to achieve this, and at the same time obviate returning heated oil to the pumps, Fuel Firing Limited's patented thermostatic valve is installed in the return main. No. 1 boiler is equipped with four of the now well-known Type FF1/80 initiators also supplied by Fuel Firing Limited, some of the main features of which are:—semi-rotary retraction of the burners when not in use, with provision for automatic complete sealing off of the opening both when the burner

is in the firing and retracted positions; each initiator has its own integral fan to ensure correct fuel/air quantities and velocities; fully-interlocking mechanically-operated oil valves; the semi-rotary action of retraction eliminates the necessity for oil-purge gear; self-cleaning electronic flame-failure protection; every part of the initiator is accessible for inspection and maintenance while the boiler is on load. The type FF1 initiator, of which there are considerable numbers in commission in modern power stations, has a number of special features which were incorporated in the original design stages as being necessary to meet the arduous duty of an auxiliary oil-burner on pulverised-fuel-fired boiler plant. The initiator is a triple purpose unit. Firstly, it is capable of raising full pressure from a cold condition when firing oil only, without risk of carry over of unburned oil and carbon to the back end of the boiler plant; secondly, due to the intense heat of the flame produced, very rapid ignition of the pulverised-fuel is achieved, so eliminating "puffs," on ignition of the coal, taking place, and, thirdly, due to its very rapid action (under two seconds from pressing the start button to being in the furnace and alight) it is arranged automatically to stabilise the furnace on the p.f. flame becoming unstable. Unlike other burners for this duty, it is not horizontally-retractable. The basis of the patented design is that the complete assembly is rotated about 90° into and out of the furnace, integral sealing plates fixed to the moving assembly completely sealing off the furnace, both in the firing and retracted positions.

Superheaters

The automatically-controlled MeLeSco superheater was designed and manufactured by The Superheater Co. Ltd., to give a final steam temperature of 925 deg. F. at 950 lb./sq. in. over the range 440,000/550,000 lb./hr. The superheater comprises primary and secondary sections—the two stage primary superheater (14,330 sq. ft. effective surface) is of the horizontal self-draining type, and is located in the second gas-pass of the boiler; the secondary section (4,140 sq. ft. effective surface) is of the pendant type, and is located at the furnace outlet. The saturated steam passes from the rear drum into the primary inlet header situated below the first stage, the connecting tubes acting as steam-cooled supports for this section. The steam passes upwards through the first and second contra-flow stages of the primary superheater to the primary outlet header. From this, steam flows through the MeLeSco spray-type desuperheaters to the secondary inlet headers and thence, in parallel flow through the pendant secondary superheater; thus the tubes of higher temperature are not located in a position of maximum gas temperature. The superheated steam at final conditions of temperature and pressure leaves the final outlet header through connections at each end. The final steam temperature is measured at each end of the final outlet header, and the resulting signals transmitted through an averaging relay to a Kent Mark 20 controller-recorder. This instrument automatically controls the International Combustion Limited pulverised-fuel tilting burners by means of four Kent pneumatic power cylinders such that the final steam temperature is maintained at the desired control setting. A secondary trimming controller actuates the diaphragm-operated control valves of the spray desuperheaters in such a way that desuperheating is introduced when the tilting burners fall to a predetermined angle of down-tilt. Biasing relays are provided to correct any out-of-balance in final outlet steam temperature. As a supervisory aid in pressure raising and in order to ensure the safety of the superheater during operation, a comprehensive system of MeLeSco Acramet permanent metal-temperature thermocouples is installed. From observation of the chart record of the Leeds & Northrop Speedomax panel instrument to which these thermocouples are connected, reliable assessment can be made of the influence of furnace conditions as reflected by the measured superheater metal temperatures.

The draught plant which was supplied by James Howden & Co. Ltd., comprises two forced-draught and two induced-draught fans. The f.d. units each have a capacity of 99,500 cu. ft./min., at a temperature of 110 deg. F., they operate at a speed of 730 r.p.m., and are driven by 254 h.p. motors supplied by Laurence, Scott and Electromotors Limited. The I.D. fans are designed for a duty of 174,000 cu. ft./min. at 305 deg. F., and a speed of 970 r.p.m. They are driven by 610 h.p. motors, also supplied by Laurence, Scott and Electromotors Limited.

The valves and mountings for each of the three boilers were supplied by Hopkinsons Limited and include torsion-bar safety valves (including electrically-assisted units), high and low water alarms, "Absolute" water gauges, Hopkinson-Ferranti valves, parallel-slide valves, electric valve controls, combined stop and non-return valves, "Uniflow" valves, spring relief valves and desuperheating equipment. Hopkinsons Limited also supplied the soot-blowing equipment for all three boilers.

Boilers Nos. 2 and 3

Dealing now with the John Brown boilers (Nos. 2 & 3), although they have the same output and steam conditions as No. 1 boiler they possess numerous significant points of difference as regards design and layout. Each unit is designed to allow for all the pressure parts to be suspended from the building structural steelwork, provision being made for the free expansion of all pressure parts in a vertically downwards direction. All pressure parts are supported independently of the casings and insulation, and are so designed that no stresses due to thermal expansion shall be transmitted to the casings or other parts of the unit. Adequate provision is made in the casing for expansion. The complete casing with its insulation is supported from the operating-floor level and the economiser level. The furnace, which is fully water-cooled, has a volume of 57,000 cu. ft. and a heating surface of 27,010 sq. ft. Natural circulation is effected by the use of large-bore unheated external downcomers which ensure an adequate supply of steam-free water to the combustion-chamber steam-generating tubes under all conditions of boiler loading. The superheater has a heating surface of 24,300 sq. ft. and is of the high-velocity two-stage type. The primary stage is of the self-draining type, arranged in counterflow, while the pendant semi-radiant secondary section is arranged for parallel steam and gas-flow. The steam temperature is controlled by means of gas by-passing over the primary section of the superheater. The linkage of the dampers at the economiser and by-pass outlets is arranged so that with rising steam temperature, the dampers in the by-pass

circuit open while those in the main circuit close by a corresponding amount; with a falling steam temperature the action is, of course, reversed. Incorporated within the unit is a Brown-Riley continuous-loop plain-tube type economiser arranged in three banks, and having a heating surface of 19,300 sq. ft. The heating surface is so arranged that during periods of maximum gas by-passing the temperature of the gases leaving the economiser remain reasonably constant. A Brown-Riley cross-flow tubular airheater having three air-passes and a total heating surface of 172,500 sq. ft. is also installed. Ten "No. 4" horizontal register-type p.f. burners with 12 in. nozzles and each complete with fully-automatic oil-ignition burners, are arranged on the front wall of each boiler in two rows of four, and one top row of two. Each boiler is served by five size-550 single Brown-Riley pulverising mills which are in turn fed by variable-speed drum-type coal-feeders. Each mill is driven by a 250 h.p. motor, through a gear reduction unit, to give a mill speed of 880 r.p.m., and is capable of handling 22,000 lb./hr. of coal. As stated above, each of the p.f. burners is fitted with a fully-automatic oil-ignition burner. These burners, which were supplied by Peabody Limited, in the case of Nos. 2 and 3 boilers, are inserted through the centre hub of the p.f. burners. The oil lighting up burners are provided with high energy ignition, burner advancing and retracting gear, flame-detection equipment, and automatic oil shut-off and purging valves; whilst continual indication of the operating state of each burner is given on the boiler main control panel. Automatic combustion-stability control, which is also provided, causes additional pilot burners to come into operation when the p.f. combustion conditions deteriorate and if this condition becomes worse, all lighting burners are closed down and an alarm signal is initiated.

The draught plant for Nos. 2 and 3 boilers comprises two forced-draught and two induced-draught fans per boiler, and these were supplied by Aerex Limited, Sheffield. The fans are of the Aerex Aeroform high-efficiency backward-bladed aerofoil pattern, the forced-draught units being arranged with a single-boxed inlet and the induced-draught units with double-boxed inlets. The F.D. fans are positioned at high level within the boiler house, and thus draw warm air from above the boilers. They are designed for a maximum duty of 86,000 cu. ft./min. and are driven by Laurence, Scott & Electromotors 254 h.p., 740 r.p.m., 3.3 kV motors of the constant-speed squirrel-cage type. Fan output is controlled by radial inlet-vanes within the fan inlet eye, operated by a hydraulic ram from the boiler control equipment. The induced-draught fans which are designed for outdoor working, are connected at their inlets to the electrostatic precipitators, and finally discharge into the chimneys. They are designed for a maximum capacity of 174,000 cu. ft./min. at 305 deg. F., and are

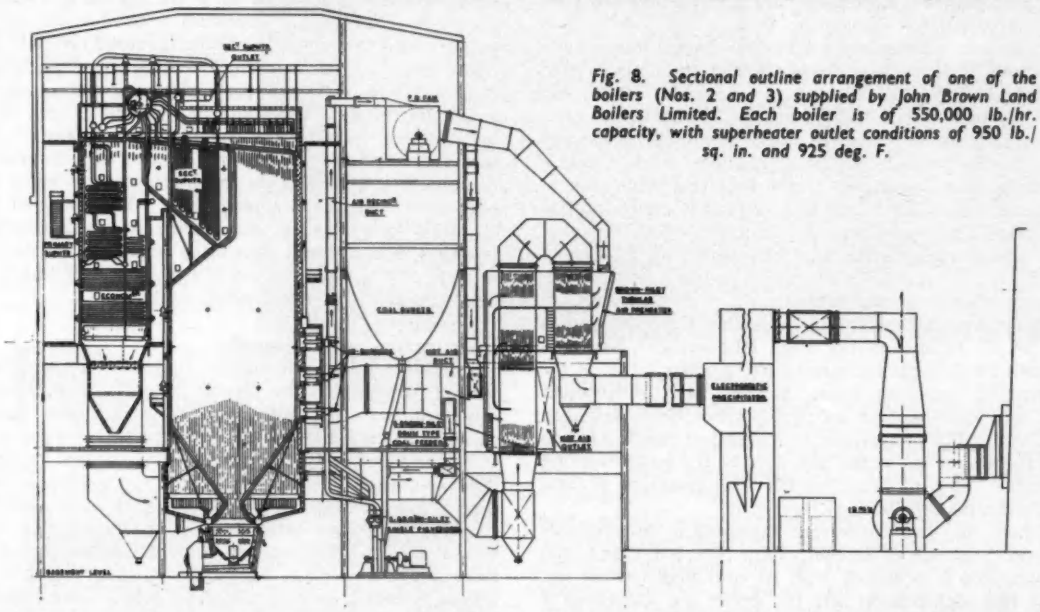


Fig. 8. Sectional outline arrangement of one of the boilers (Nos. 2 and 3) supplied by John Brown Land Boilers Limited. Each boiler is of 550,000 lb./hr. capacity, with superheater outlet conditions of 950 lb./sq. in. and 925 deg. F.

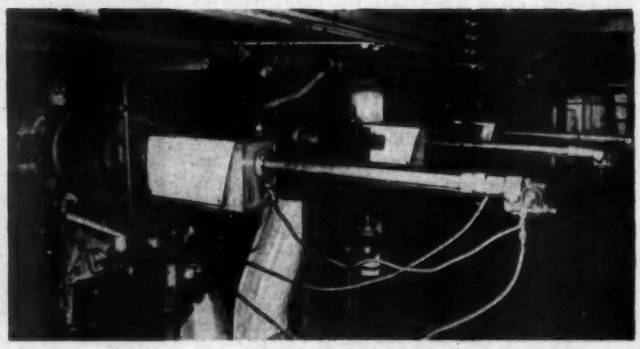


Fig. 8. View along firing face of No. 2 boiler, showing Peabody oil lighting-up burners which are inserted through the centre hub of each p.f. burner.

each driven by a 266 h.p. Laurence, Scott constant-speed squirrel-cage motor operating on a 3.3 kV supply. As in the case of the F.D. fans, output is vane controlled.

The heat insulation work on No. 1 boiler, including the drums, superheaters, flues, ducting and integral pipework was carried out by Versil Limited, Liversedge, Yorks. This company were also responsible for insulation of the high-pressure steam piping on all three boilers, and incidentally of the complete condensing and feed-heating plant for the three 60-MW generating sets.

The heat insulation work for the drums, heaters and integral piping, for Nos. 2 and 3 boilers, and for associated ducting, both inside and outside the boiler house, was the responsibility of The Darlington Insulation Co. Ltd., using Darlington brand materials. A special feature was the weatherproofing of the insulation on the outside ducting with Darlington armouring compound (A.C.1) instead of the usual bituminous material. The Darlington company also carried out the insulating of the whole of the oil-fuel piping on each of the three boilers.

Electrostatic precipitators

A "Holmes-Elex" electrical precipitator, supplied by W. C. Holmes & Co. Ltd., Huddersfield, has been installed before the i.d. fans of No. 1 boiler. It is of the horizontal gas-flow type, having two independent sections, each section containing three fields arranged in series. The precipitator is designed to handle 243,000 cu. ft./min. of gas at 280 deg. F. with the boiler working at c.m.r. The inlet dust burden is 7.7 grains/cu. ft., and the collection efficiency 97.5 per cent.

There are two Sturtevant electrostatic precipitators provided for each of the boiler units Nos. 2 & 3, and each precipitator is equipped with its own high-tension set. The two high-tension sets per boiler are located in a common house, and are interconnected on the output side so that during maintenance, one may be shut down whilst the other supplies both precipitators. In cases when maintenance is required on the precipitator without taking the boiler "off load," it is necessary to take gases through one precipitator by a suitable arrangement of dampers on the inlet and outlet ducting. The gas-cleaning plant is designed to give, at normal maximum continuous rating, an outlet flue dust burden to the chimneys of 0.166 grains/cu. ft. at N.T.P., based on the design fuel. The gas from the air-heaters enters flues which are built as an integral part of the precipitator casing, and run the full length of each side of the casing. The gas enters the main body of the precipitator through subsidiary ports, located in the casing wall inside the flue, circulates around the outside of the tube banks, and at the same time passes downwards to the lower end of the tubes. Here, the gas turns upwards, passing through the tubes where it comes under high-tension electrical influence set up by the discharge and receiving electrodes. It is impossible for any of the gas to by-pass the treatment zone, and after treatment it passes to the ports into the main outlet flue, which is again integral with the precipitator casing. The precipitator is divided into three sections to improve gas distribution, and skirt-type baffles are fitted around the lower end of the tube banks. Rapping gear is provided for both the tubular receiving electrodes, and the discharge electrode wires. The latter are rapped by means of mechanically-operated swing falling hammers which rotate with the shaft and strike the top grids once in every operating cycle of the shaft. The tubular receiving electrodes are rapped by out-of-balance rotary vibrators mounted on each side of the casing. There is one high-tension set, of Sturtevant mechanical rectifier type for each precipitator, and an automatic voltage control unit is provided to each H.T. set to select the optimum voltage for the plant to give maximum efficiency. Remote control and indication equipment is provided on the boiler control panel for high-tension sets and rapping gears. The whole of the electrical equipment for the precipitators is interlocked both mechanically and electrically making it impossible to enter any charged portion of the plant until that part has been shut down and safely earthed.

Instruments and controls

The automatic boiler control equipment for all three boilers was supplied by George Kent Limited, Luton, and comprises master panels, boiler panels, boiler control desks and transmitter panels. Instruments dealing with such variables as fuel control, forced-draught control, induced-draught control, mill-feeder control and superheater outlet pressure, etc., include the Mark 2 Multilec stripchart recorder/indicator. Transmitters for the measurement of flow, oxygen content, conductivity and temperature have been supplied, as have various Kent "Commander" instruments for electric transmission of flow, pneumatic transmission of pressure, reception of pressure and ratio control of steam/air flow. Kents also supplied instruments for flow transmission, electric pressure transmitters, F.A.F. thermostatic pressure controllers, and Kent master pressure-indicator controls.

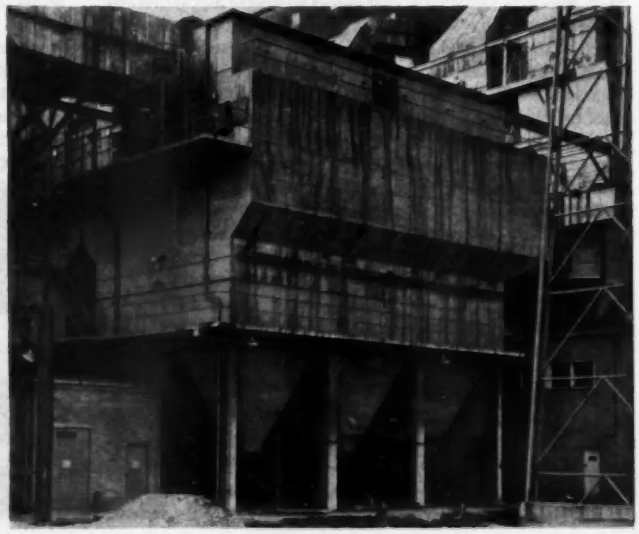


Fig. 9. There are two electrostatic precipitators provided for each of Nos. 2 and 3 boiler units, and they were supplied by Sturtevant Engineering Co. Ltd.

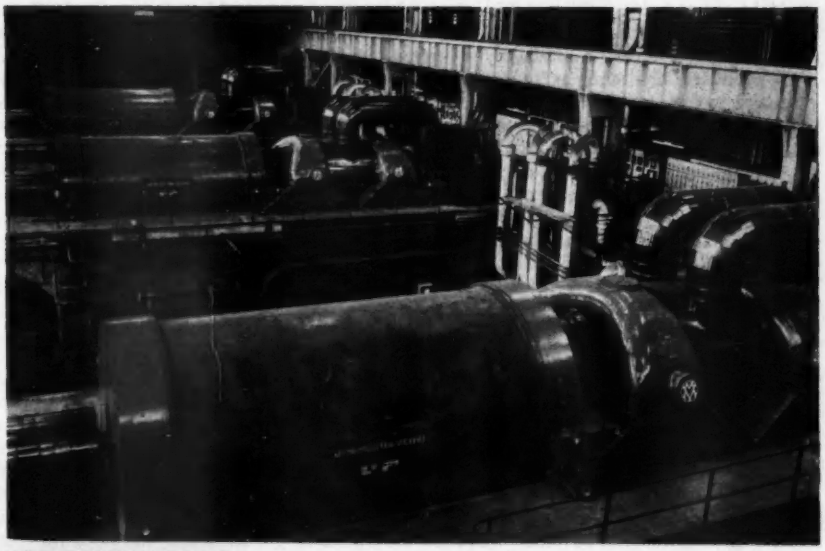
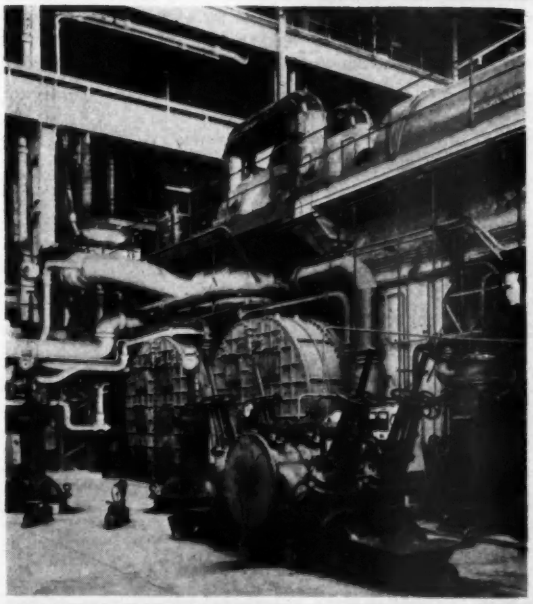
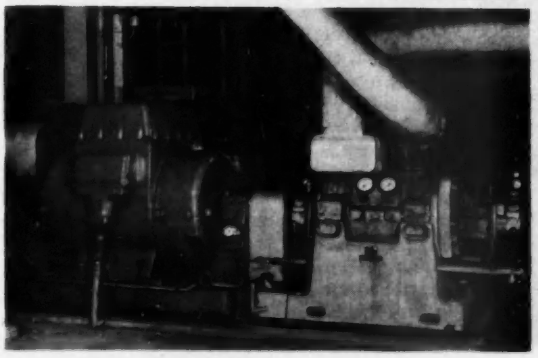


Fig. 10 (right). The three 60-MW turbo-alternator sets were supplied by Metropolitan-Vickers (now A.E.I.) Limited.

Fig. 11 (centre below). Basement view showing the Vickers-Armstrongs (Engineers) Limited condensers for No. 2 set.

Fig. 12 (bottom). The six boiler feed pumps (two per set) were supplied by Sulzer Bros. (London) Limited.





Ash-handling plant

The ash-handling plant was supplied by Babcock & Wilcox Limited. The furnace ash is discharged into ash-hoppers situated immediately beneath the boiler furnace throat, the hot ash being quenched by means of water-nozzles. The ash is then discharged by means of high-pressure water-jets into a sluice-way where, with the aid of auxiliary water-jets placed at intervals along the length of the sluice, the ash and water mixture passes through crushers where the ash is reduced, and then discharged into a sump immediately below. The dust from the precipitator and airheater hoppers is removed by means of feeder-ejectors discharging into sluiceways which transport the slurry to the ash sump in a similar manner to that described for the ash. The economiser dust is removed by means of wind-swept dust valves working in conjunction with Hydrovactors and is discharged into sluiceways connected to the ash sump. The slurry and water mixture in the common ash sump is pumped through thick-walled cast-iron pipes to ponds surrounding the station. The ponds have been formed by the extraction of gravel, and when filled with ash they will be topped with soil, levelled and grassed.

The two Babcock "D"-frame ash-pumps are driven through Vulcan-Sinclair size-26 SCR5 scoop-control fluid couplings, giving variable speed regulation from 705-405 r.p.m., the S.C. motors being rated at 80 h.p. at 735 r.p.m., while the two Babcock ash crushers are driven by 10 h.p., 730 r.p.m. S.C. motors through size-16.25 traction type fluid couplings. All these fluid couplings were supplied by Fluidrive Engineering Co. Ltd.

Turbo-alternators

The three turbo-alternator sets are all of Metropolitan-Vickers (now Associated Electrical Industries Limited) manufacture. Each is designed to run at a speed of 3,000 r.p.m. and has a maximum continuous rating of 60-MW, with turbine stop-valve steam conditions of 900 lb./sq. in. and 900 deg. F., and with 28.7 in. vacuum at the

low-pressure exhaust. The turbines are two cylinder machines having the high- and low-pressure turbine rotors rigidly coupled together by a bolted coupling. Both cylinders have annular steam belts at the various extraction points to enable steam to be drawn from the complete periphery, instead of from localised areas, thus preserving thermal balance. Inter-stage drainage, where necessary, collects and leads condensed steam to a heater belt, or to the exhaust-chamber. The complete turbine-rotor is supported by three spherically-seated bearings; one at each end of the shaft, and the third carried by the centre pedestal, between the high-pressure and low-pressure cylinders. A Michell-type thrust block is combined with the high-pressure inlet-end journal bearing. Steam enters the turbine at 900 lb./sq. in. and 900 deg. F., by way of two cast molybdenum-steel steam-chests, fitted with governor valves and two combined stop and emergency valves. The emergency stop-valves are operated either automatically, by duplicate emergency overspeed governors mounted on the turbine shaft and set to operate at a speed of 3,3000 r.p.m., or they may be tripped instantly by hand.

Speed regulation is effected by a centrifugal governor, operating the governor valves through an oil relay system. Hand and motor-operated speeder gear enables the turbine speed to be raised or lowered above or below normal. Load pay-off gear is fitted, which reduces load on the turbine automatically should the condenser vacuum fall below 25 in. Hg. for any reason. At the turbine exhaust flange, the steam leaving the low-pressure cylinder passes to the condenser, at a vacuum of 28.7 in. Hg. at the 60-MW rating. The low-pressure end-pedestal carries motor-operated barring gear, which is brought into operation to eliminate rotor distortion due to uneven temperature distribution after shut-down. The barring gear turns the rotor at approximately 2 r.p.m. To provide the turbine operator with a guide to conditions regarding axial-expansion, running clearances and the degree of eccentricity of the rotor, a comprehensive system of supervisory control is installed.

Twin condensers of the three-pass type, are fitted below the low-pressure cylinder, the total surface cooling area being approximately 60,000 sq. ft. The condensate is extracted from the condenser by two 100 per cent. duty extraction pumps supplied by Drysdale & Co. Ltd., one of which has been installed as a stand-by unit. Each extraction pump has a capacity of 750 gal./min. and pumps the condensate through three low-pressure heaters, the third of which is a high-level combined feedwater-heater and deaerator, which removes any gases which may have become entrained in the water. From the deaerator the water passes to the inlet of the feed pumps.

The condensing and feed-heating plant, which was supplied by Vickers-Armstrongs (Engineers) Limited,

Fig. 13 (right). Auxiliary plant house showing (at right) the 600 cu. ft./min. Worthington-Simpson rotary air-compressors.

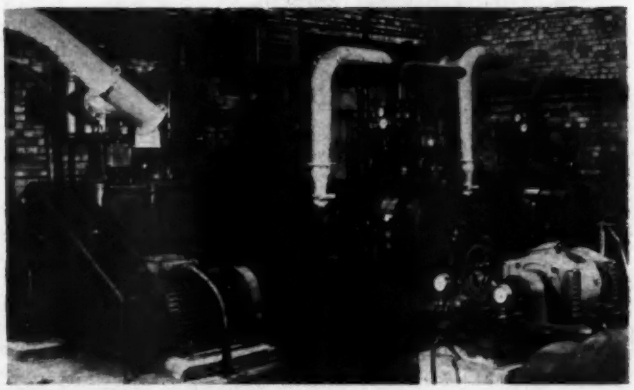
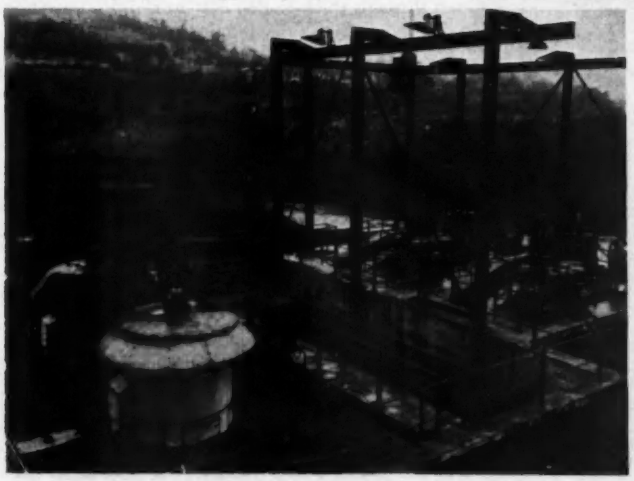


Fig. 14 (below). Circulating-water pumps and band-type screens. The pumps were supplied by Drysdale & Co. Ltd.



comprises the following units and inter-connecting pipe-work. The condensers are twin-shell, three-pass units, with fabricated bodies and cast-iron waterboxes, taking 36,500 g.p.m. of cooling-water at the machine's maximum continuous output of 60-MW. At a cooling-water inlet temperature of 65 deg. F., the exhaust steam from the L.P. turbine is condensed under feed-heating conditions at full load, maintaining an absolute pressure at the turbine exhaust of 1.3 in. Hg. Any air present in the condenser steam space is removed by one or two 100 per cent. duty main ejectors of the vertical, three-stage type with inter-stage condensing. The steam supply to these units is at a pressure of 850 lb./sq. in. and a temperature of 898 deg. F. The feed train comprises the ejectors already mentioned, drains cooler, No. 1 L.P. water-feed heater, a gland steam condenser and the No. 2 L.P. water-feed heater. From the latter, the

extraction pump lifts the condensate to the high-level deaerator, which comprises a vapour condenser, deaerating chamber and a large storage-vessel of sufficient capacity at normal working level to provide for 10 min. running at c.m.r. The feed system, therefore, consists of three low-pressure and two high-pressure heaters arranged, as far as possible, to provide the most efficient distribution of sensible heat rise of the feed water over the respective heaters. One of the low-pressure heaters is actually the high-level deaerator referred to above, deaeration being carried out at a pressure above atmospheric at all loads over 50 per cent. The remaining heaters are of the vertical surface type with hairpin tubes.

Float-operated alarm and safety devices are fitted to the condenser, deaerator and H.P. heaters as a precaution against the flooding of these units. In addition, the deaerator storage-chamber is fitted with float-operated devices, which actuate air-operated valves to ensure that the level does not fall below a pre-determined point. At the continuous maximum rating of 60-MW the feed train passes 51,500 lb./hr. of feed to the boilers, the outlet temperature at the final H.P. heater being 385 deg. F.

The direct-coupled alternator is driven by the turbine through a semi-flexible coupling. At 3,000 r.p.m., it is rated at 60-MW, 0.8 power factor, and generates three-phase, 50 c/s alternating current at 11.8 kV. The stator yoke is of circular box-girder construction in welded steel, with strongly reinforced end shields. The rotor, which is carried by two white-metalled journal bearings, is machined from a forging of special alloy-steel. Cooling

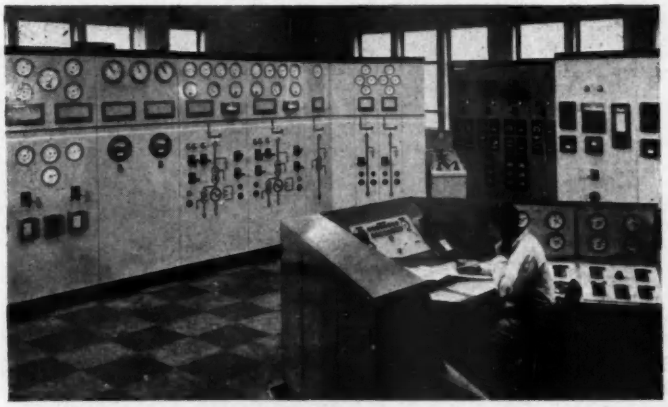


Fig. 15. General view in station main electrical control room.

is achieved by the use of hydrogen at a pressure of 15 lb./sq. in. g., which is circulated throughout the alternator by fans on each end of the rotor shaft. The hydrogen is cooled by passing it through water-cooled tube-nests of finned tubes which are arranged axially between the stator core and the outer casing; complete equipment is also installed for maintaining the purity of the hydrogen. Main and pilot exciters are direct-driven from the end of the alternator shaft.

There are six boiler feed-pumps—two per boiler, and they were supplied by Sulzer Bros. (London) Ltd. They are of the barrel-casing type, arranged for centre-line mounting and provided with six stages. Each pump is designed to deliver 650,000 lb./hr. of feedwater at a temperature of 260 deg. F. against a pressure of 1,165 lb./sq. in. when running at 2,950 r.p.m. The pumps are driven by 3.3 kV, 1,325 h.p., two-pole squirrel-cage induction motors supplied by Metropolitan-Vickers (now A.E.I.) and arranged for direct-on starting. It is interesting to note that more than 60 boiler feed-pumps of the above-mentioned capacity have been supplied by Sulzer Bros. (London) Ltd. to serve boilers of similar outputs in various C.E.G.B. power stations, and in the case of Elland, Sulzer Bros. have also supplied various auxiliary service pumps. Make-up water is admitted to the system depending on the level of water in the deaerator tank, a system which has proved most efficient and flexible. The water-tanks are located at two levels in the boiler house, the main tanks being at roof level with a secondary tank some distance below, but above the deaerator level. Raw water for make up is taken from the town's water supply and supplemented by a borehole well which has been sunk at the south-west corner of the site, and from which approximately 10,000 gal./hr. are obtained. The shaft of this well is 450 ft. deep. The raw water is treated in a Neckar ion-exchange softening system before being fed to the feedwater storage tanks.

Water treatment plant

The water-treatment plant, supplied by Neckar Water Softner Co. Ltd., will treat 8,000 gal./hr. of raw water from the Halifax town main, or, in an emergency from the site borehole, for boiler make-purposes.

These waters have very different characteristics. The borehole water is first filtered through six pressure sand filters, utilised from Thornhill Power Station, and then passed through a multi-stage deionisation plant consisting of a strongly acidic cation exchanger, weakly basic anion exchanger, degasser tower and twin monobed (mixed bed) scavenger exchangers. After removal of CO_2 in the degasser tower, the water is collected in a sump below floor level and pumped through the monobed exchangers to storage tanks. The Halifax town main water, normally requires treatment in the monobed exchangers only, but a feature of the plant is that the layout is arranged so that this water may also be pre-treated and filtered if considered necessary. Vessels are provided for bulk storage, in concentrated liquid form, of the regenerant chemicals, sulphuric acid and caustic soda. These chemicals are pumped to measuring ranks situated at a level above the main plant where they are diluted in mixing tanks and delivered by ejectors to the ion-exchangers when regeneration is required. Built-up open channels are run above floor-level to a common drain for collection of waste effluent from the exchangers. This overcomes the necessity of providing a network of built-in drain pipes in the floor. The final treated water is of high quality, having an electrical conductivity of 0.2 to 0.5 microhms/cm.[3] and a silica content of 0.05 p.p.m. This water is continuously tested automatically for conductivity and alarm systems are incorporated to indicate when regeneration of the ion-exchangers is required. Recorders, mounted in an instrument panel, keep a record of the quantity and quality of the treated water passed to service.

Metal Failures Encountered in Power Plant

By N. S. MARTIN, A.I.M., Assoc.M.C.T., A.M.Inst.W.

THE failure in service of metal components which form part of the steam-generating, turbine or condensing plant in a power station is probably the cause of most "outage time" of the plant concerned. With a modern large unit station, this "outage" time can often be extremely expensive.

The object of this article is to outline the more common types of failures which occur, in order to assist those concerned, with the identification of the various failures with which they come into contact, and to give some indication as to the possible causes of failure.

One of the larger insurance companies, in a technical report which was issued a few years ago* listed the causes of failure of steam raising plant components in the following order:

		per cent.
Attributable to service conditions	Corrosion fatigue	33
	Caustic cracking	18
	Overheating and creep	17
	Corrosion	10
	Stress corrosion	4
	Fatigue	2
	Strain age embrittlement	2
	Penetration by molten metal	1
	Overpressure	1
Attributable to other factors	Defective material	7
	Defective workmanship	5
		100

This analysis was based on the examination of 217 cases of failure. Since this report was issued, there has been a considerable amount of work carried out on the detection and prevention of both corrosion fatigue and caustic cracking, and it is very probable that if a similar analysis were to be carried out at the present time, the principal cause of plant failure would be found to be overheating and creep, followed by corrosion.

Type of failure

(1) *Overheating and creep*

The great majority of superheater tube failures which occur, are due to the application of excessive temperature to the superheater material. Under these conditions, the internal steam pressure causes the tube to bulge through plastic deformation of the metal until ultimately failure occurs. A typical example of this type of failure is shown in Fig. 1. The main failure is invariably a split along the length of the tube at right-angles to the applied stress, and it is usually accompanied by cracks in the oxides present on the surface of the tube, both internally and externally. These cracks are the result of plastic deformation (i.e., swelling) of the underlying metal, the inherently brittle oxide being unable to similarly deform. This external oxide cracking can be observed in Fig. 1. The cracking of the oxide exposes clean metal to the strongly oxidising atmosphere, and preferential grain boundary oxidation of the metal results in fissures being produced as shown in Fig. 2, adjacent to, and in the same direction, as the main failure.

One of the characteristics of creep failure is the multiple cracking which is produced, the cracking being at the grain boundaries at right-angles to the maximum applied stress. This point is illustrated in Fig. 3. The microstructure of the overheated steel varies considerably from that of the original material. The carbides originally present as pearlite may have completely spheriodised and may even have migrated to form a brittle grain boundary film. Graphitisation may have taken place at a later stage, some graphite nodules being shown in Fig. 3.

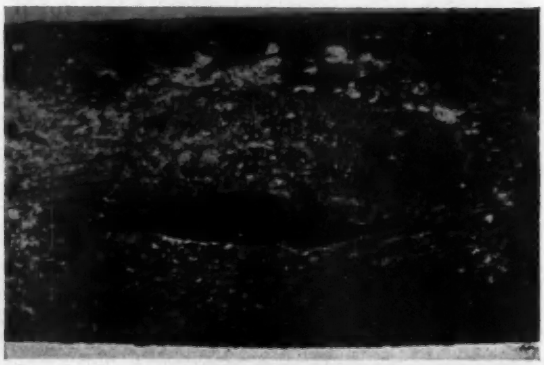


Fig. 1 (above).

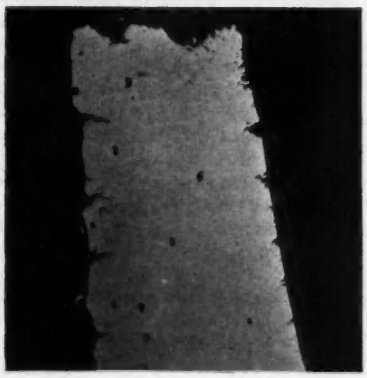


Fig. 2 (right).

*British Engine Boiler and Electrical Insurance Co. Ltd., Technical Report, volume III.

(2) *Corrosion fatigue*

As already stated, this type of failure is not now so prevalent, but it still occurs frequently enough to merit its inclusion in this article. The cracking which occurs is invariably multiple in nature, and when it appears in such components as tubes, the cracks are always transverse to the tube axis. A typical example of corrosion fatigue cracking in an economiser tube is shown in Fig. 4, whilst Fig. 5 illustrates the more readily-found cracking in a steam valve body. In both these cases, the cracking has been caused by intermittent wetting of a hot surface, the thermal stresses being sufficient to initiate cracking. The cracks are usually much deeper than would be thought on visual examination, and when examined microscopically, show certain typical features. The path of the crack is usually perfectly straight, at right-angles to the surface at which it originates, and the cracks are normally broader at their origin than at their tips. Usually, they are filled with corrosion products, down which there is often a central crack. Corrosion fatigue cracks are completely transgranular in nature, and Fig. 6 shows a typical example, where the crack within the oxide infilling can be seen. Usually, little repair work is possible on component parts found to have this type of cracking, because of the multiple nature and the depth of the cracks.

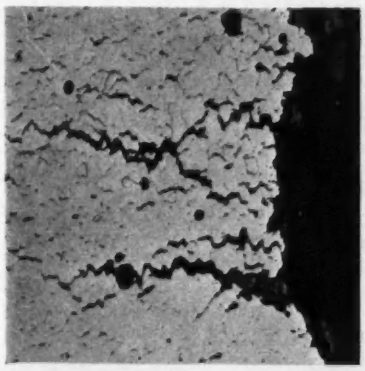


Fig. 3 (left).

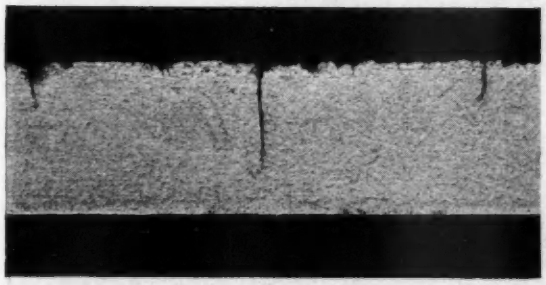


Fig. 4 (below).

(3) *Caustic cracking*

Again this form of failure is now not so common, but cracking is still being found in older plant with riveted seams. The basic cause of this type of failure is the presence of a residual stress in the steel component together with a concentration of sodium hydroxide. These two requirements can very easily be met in a riveted seam of a boiler drum when a leakage path has established itself. Considerable residual stresses can be present arising from the original riveting or from caulking the joints, and as the leaking boiler water, containing chemicals in solution, passes through the joint, it is concentrated and evaporated to atmosphere, leaving behind a strong solution of boiler water chemicals, including sodium hydroxide (caustic soda). The actual attack on the steel is a stress corrosion type of attack, the cracking which takes place being completely intercrystalline. In cases of advanced attack, the cracking usually runs between rivet-holes and across the rivets at the heads. Fig. 7 illustrates an example of caustic cracking in a boiler plate, whilst Fig. 8 shows a section through a rivet in which cracking has taken place. On micro-examination, the cracking can be seen to be completely intergranular with preferential attack on the carbide constituent in the pearlite which is present. Fig. 9 illustrates a typical crack. Associated with the cracking is usually found a layer of brightly crystalline magnetic iron oxide (Fe_3O_4) in the gaps in the joints between the drum and butt-straps, and also in the rivet holes. This oxide scintillates in the light and is always indicative of the presence of caustic soda solution, from which it has been precipitated.

(4) *Other forms of caustic attack*

A form of attack known as " hydrogen embrittlement," " hydrogen cracking " or " on load corrosion," has been known for some years and many failures, particularly in boiler tubes, have taken place. These failures are sudden and occur with explosive force due to a section of the tube

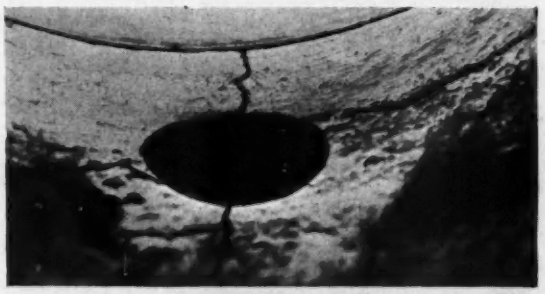


Fig. 5 (above).

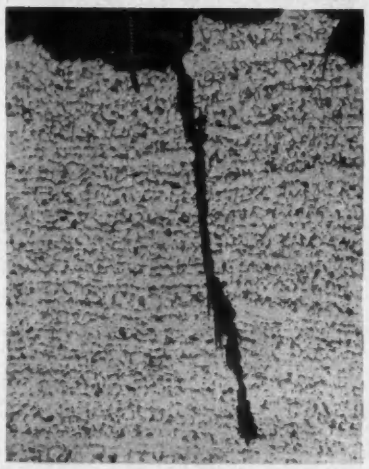
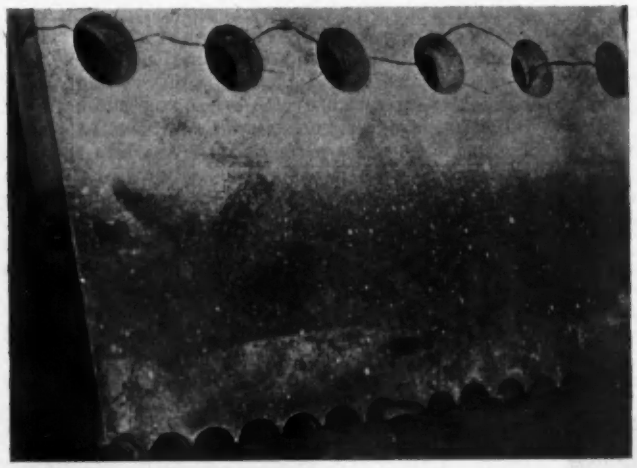
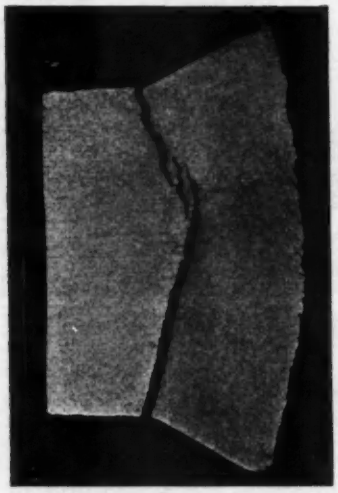


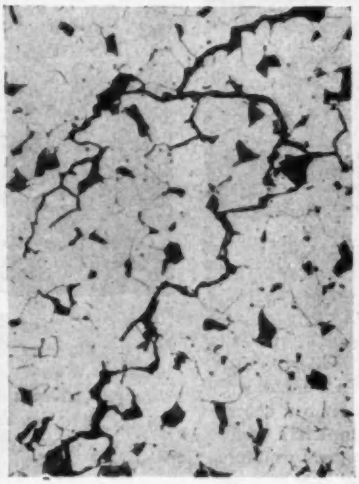
Fig. 6 (right.)

being literally blown out, leaving in the worst cases, an open-ended tube. When a failure of this type occurs, there is little left, other than the tube metal itself, of the evidence of corrosion, all the corrosion products being washed or blown away at the time of failure. If an incipient failure can be found by non-destructive testing techniques, an examination of the area of attack shows the presence of an intensely hard laminated deposit of magnetic iron oxide in the form of a scab on the inner wall of the tube. Beneath this layer, metal wastage has occurred in the form of general corrosion, but a further form of attack which is not so obvious has also taken place. One possible mechanism of attack is believed to be the penetration of gas into the metal via the grain boundaries, and the combination of this gas (believed to be hydrogen) with the iron carbide (Fe_3C) which is a constituent of the pearlite in the steel, to form methane (CH_4) has led to the grain boundaries being pushed apart. This grain boundary fissuring penetrates outward through the metal until, ultimately, there is insufficient unaffected metal left to withstand the internal pressure and the tube then bursts, usually explosively. This fissuring effect can be revealed by boiling a ring, cut transversely from the tube, in 50 per cent. hydrochloric acid. The metal which has been attacked in this way is clearly shown as a black etching area. This is shown in Fig. 10, whilst Fig. 11 shows the grain boundary fissures present in an unetched specimen. The affected area has been almost completely decarburised due to the combination of carbon with hydrogen, and oxide penetration has taken place beneath the Fe_3O_4 scab, along the grain boundaries. Fig. 12 shows the etched appearance of the same area, where very little carbide can be seen.

A similar form of metal wastage is sometimes found in inverted "U" type desuperheaters, mainly in the vicinity of the tube-plate. Fig. 13 shows a typical failure just above the expansion where the metal surface has been covered by a sludge of boiler water salts (mainly caustic soda) which has collected on the tube-plate. Fig. 14 shows the top bend of one element from the desuperheater from a boiler where "hydrogen attack" or "on load corrosion" was causing repeated failures of generating tubes. This element had been in service for about eight years, and the section shown was situated some 10 ft. above the tube-plate. The corrosion which has occurred is due to caustic soda and considerable hydrogen penetration has taken place. Metal removal has been effected over the whole of the water side of the desuperheater, with a build-up of magnetic iron oxide on the tube surface beneath which the attack has taken place. Many perforations were present in the tubes.







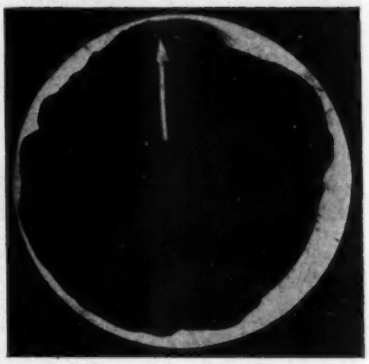
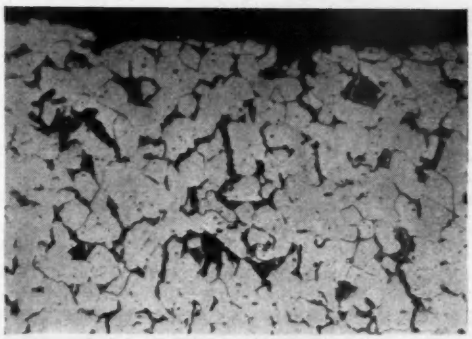


Fig. 7 (left). Fig. 8 (below, left). Fig. 9 (below, centre). Fig. 10 (below).

The precise mechanism of this attack has still to be proved, but it is believed that caustic soda which concentrates in a pre-formed iron oxide deposit is responsible for both the general metal wastage beneath the scab which forms, producing sodium ferroate ($Na_2Fe\ O_2$) and hydrogen in the atomic form. The hydrogen which is not flushed away is thus free to penetrate the steel in the manner described. On cooling down, the sodium ferroate solution is unstable and breaks down to precipitate Fe_3O_4 and sodium salts. Cases have been known where all the symptoms of this form of attack are present except for the grain boundary fissures. It is possible in these

cases that the circulation of water is sufficient to sweep away all the hydrogen as it is formed, leaving only the laminated, intensely hard F_3O_4 scabs beneath which general metal wastage takes place. In these cases, failure occurs through general metal wastage by corrosion.



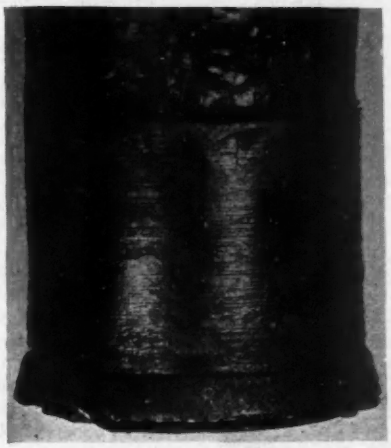


Fig. 11 (top).

Fig. 12 (above).

Fig. 13 (left).

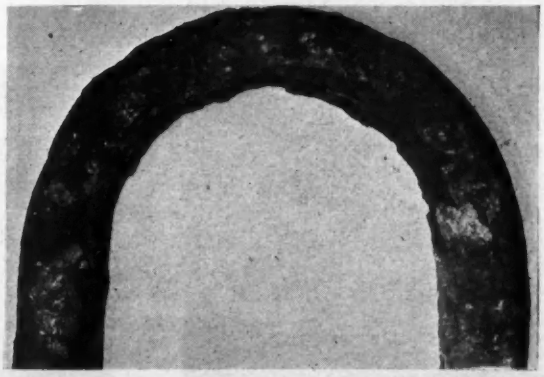
Fig. 14 (right, upper).

Fig. 15 (right, lower).

(5) *Stress corrosion*

As its name implies, this type of failure is brought about by stresses in the material, either residual or applied, in the presence of a corroding medium such as boiler water or atmospheric corrosive gases. A well-known example of this type of failure is that of 0.5 per cent. molybdenum, creep-resisting steel. Very many superheater-tube failures occurred some years ago, and failures are still occurring in this material. The failure usually takes the form of a fine hair line type of crack, often at an angle of 45° to the longitudinal axis of the tube. A typical example is shown in Fig. 15. The crack itself is completely inter-granular, and it has no other distinguishing features. If hardness measurements are carried out, it will be found that the material in the vicinity of the crack is considerably harder than the bulk of the material, and it will also be found that the crack is fairly near to a bend or a set in the tube or, failing this, that there is an indentation in the tube surface such as may be caused by a hammer-blow. Even an arc mark, where a welder has inadvertently caught his electrode on the tube has been known to cause a failure of this type. This material has very poor stress relaxation properties up to the temperature limit at which it operates (900 deg. F. maximum) and the residual stresses which are present can only relieve themselves by crack formation. Had a high temperature heat-treatment been carried out after fabrication, thus removing the stresses, no failure would have occurred.

An example of a stress corrosion failure in a low carbon $\frac{1}{8}$ in. dia. bolt is shown in Fig. 16. This bolt was used within the casing forming the air-cooling system in a turbo-alternator, and was typical of twenty similar failures found at the same time. Fig. 17 shows the crack itself which is again completely intergranular in nature. The alternator atmosphere was known to contain oxides of nitrogen resulting from ionisation of the atmosphere due to corona discharge, and it is assumed that the tensile stress in the bolts, concentrated at the change of section where the head and shank meet, together with



the corrosive gases in the atmosphere have been sufficient to cause failure by stress corrosion.

The various austenitic stainless steels in use in power plant equipment are very prone to failure by stress corrosion. One example is in the cracking found in the coil binding rings (end bells) from 33 kV, 1,500 r.p.m. turbo-alternators. These rings are forged from 8 per cent. Mn, 4 per cent. Cr, 0.7 per cent. C, fully austenitic steel and are work hardened in forging to give a yield stress of

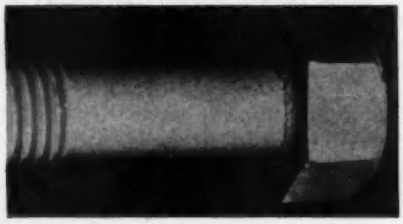


Fig. 16.

45 tons/sq. in. Such a high yield stress is necessary to withstand the working stresses of the ring in service, but it unfortunately leaves the ring with small zones of high residual stress concentrations. In this particular case, the alternator rotor, of which the ring was a component, was again running in an atmosphere containing corona discharge products together with airborne particles containing nitrates, chlorides and sulphates. Deposits collected from the system showed the presence of 40/50 per cent. nitrates, 0.2/0.8 per cent. sulphates and 0.5/3.0 per cent. chloride, in the water-soluble fraction of the deposit. The deposit itself was between 20/30 per cent. water-soluble. Multiple cracks were found to be present all round the ring, but they were only revealed by dye penetrant examination. When examined microscopically, the cracking was mainly intergranular as shown in Fig. 18, with some transgranular cracks of much shallower depth as shown in Fig. 19. Laboratory tests have shown that the intergranular cracking is probably associated with the nitrate/sulphate attack whilst the transgranular cracking is associated with the chloride attack.

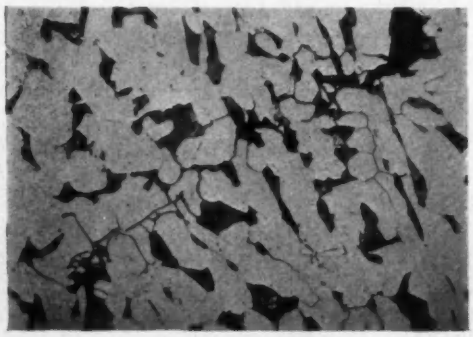


Fig. 17 (above).

Fig. 18 (left).

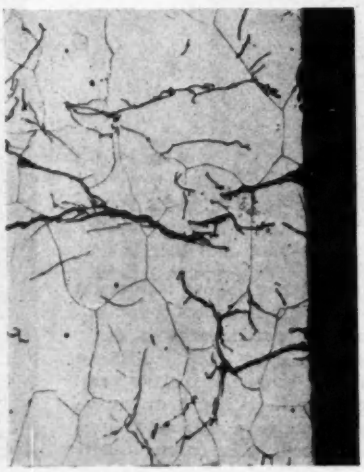


Fig. 19 (right).

(6) *Pitting corrosion*

Boiler feedwater in most modern boilers is treated in such a way that the dissolved oxygen content of the water is extremely low, being of the order of 0.03 p.p.m. Chemical additions are also made to the water, to look after the small residual amount of oxygen still present, so that the occurrence of failures in the system due to oxygen pitting has been reduced very considerably in modern practice. There are still occasional failures due to the presence of dissolved oxygen, however, particularly in older plant, and a typical example of the internal appearance of this form of failure is shown in Fig. 20. The pit produced is normally filled with soft black magnetic iron oxide Fe_3O_4, often with a cap of red Fe_2O_3. The deposits are easily removable from the pit which, once initiated by an oxygen bubble on a tube wall, is very deep in relation to its diameter. The spot on which the attack is initiated becomes cathodic towards the metal surrounding it, and a cap of corrosion products begins to form around the bubble, as a film of iron hydroxide. The oxygen in the bubble is rapidly used up in oxidising the corrosion products of the electrolysis until, ultimately, the direction of the electrical current is reversed and the base of the pit which has now formed, becomes anodic to the surrounding metal. Pitting will now continue as long as there is a difference in oxygen content between the base of the pit and the surrounding material which is now the cathode of the electrolytic cell, and ultimately perforation of the tube occurs.

A similar mechanism of attack occurs in tubes which are drained, and left standing for some time with water lodged in non-draining pockets. Oxygen absorption from the atmosphere increases the dissolved oxygen content of the water, with a lowering of the pH, and pitting corrosion occurs. Fig. 21 illustrates a superheater tube of the "self-draining" type (i.e., horizontal legs) which was drained and left with condensed-water lodged in the legs. The element was standing for a matter of a few weeks whilst plant over-

haul work was carried out, and failure of the element occurred when the boiler was returned to service.

(7) *Copper penetration*

It is frequently necessary to carry out repair work which involves welding on boiler and superheater tubes, by welding-in a short length of tube to replace a section in which failure has taken place. Unless the necessary precautions are taken, it is not infrequent to find further failures in the immediate vicinity of the welds of this type and a micro section through an example of a typical failure shows two features. Firstly, corrosion fatigue cracking is present, this being the cause of the failure in the original tube and, secondly, the cracks and surface

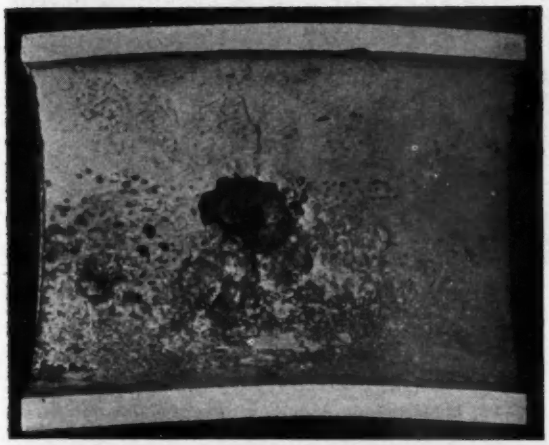


Fig. 20 (left).

Fig. 21 (below).

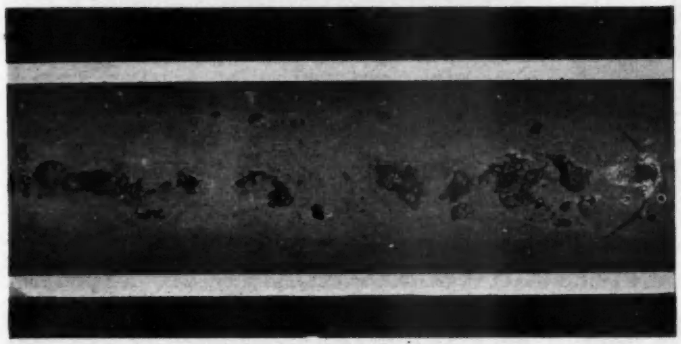
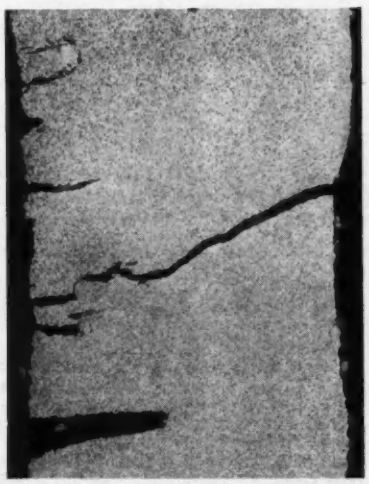


Fig. 22 (right).



crevices can be seen to be filled with metallic copper. These features are shown in Fig. 22. When examined at a higher magnification, the copper is seen to have penetrated along the grain boundaries of the material in the area of failure, the main failure being as shown in Fig. 23 where the copper forms a continuous film from the end of the corrosion fatigue fissure to the outer-wall of the tube. This type of failure is always associated with a distortion of the grain structure of the steel where copper penetration has occurred, one such distorted area being shown in Fig. 23. The failure has been caused by welding the replacement tube in position without cleaning the bore of the old tube adequately. Metallic copper is invariably present in the oxide layer of any boiler or ancillary pipe work, and the temperature in the vicinity of the weld is sufficient to melt the copper and to allow it to penetrate the grain boundaries of the steel, both in the sound metal, and at the base of the corrosion fatigue fissures which were left in the tube. Adequate cropping, combined with examination by magnetic crack detection would have ensured that the fissuring was completely removed, and removal of the oxide layer for 2 in. on either side of the weld preparations would have removed any copper deposits which could cause trouble of this sort in welding.

(8) *Dezincification of brass components*

All the types of failure described up to now are associated with ferrous metals. Extensive use is made of copper alloys in power plant, however, and one of the common types of failure, particularly of older components, of brasses in contact with water is dezincification. This involves the chemical solution of both copper and zinc from the alloy, with the simultaneous re-deposition of the copper in a spongy form. The re-deposited copper is very porous in nature and has little or no mechanical strength. The necessary conditions for this form of attack to take place include the presence of a slightly acid water or an acid atmosphere. With the single-phase 70/30 types of brass, the addition of arsenic in very small amounts during manufacture of the alloy, completely stops this form of attack but in duplex types of brass of the 60/40 types, the addition of arsenic does not necessarily give immunity from dezincification.

(9) *Scaling of 70/30 cupro-nickel tubes*

Wide use has been made of cupro-nickel alloys in tube form in heat-exchangers, amongst these being the 70/30 copper nickel, the 80/20 and the 90/10 copper nickel alloys. An unusual and as yet unexplained type of corrosion, has been found in many heat-exchangers using 70/30 or 80/20 cupro nickel tubes, the attack taking the form of a black exfoliating scale which breaks away from the tubes in long flakes. It is preceded in the earlier stages by the tubes taking on a coppery appearance which micro examination and analysis show to be a denudation of nickel. Fig. 24 shows a typical example of this attack and the loose scale which is produced.

Analysis of the scale shows it to consist of copper and nickel oxides in the same proportion as the parent metal. This attack was thought originally to be confined to 70/30 cupro nickel tubes, but failures in 80/20 material have occurred also, and it was believed for some time that the content of the alloy below 22 per cent. This type of corrosion appears to be associated only with stations which are running under conditions of fluctuating operation. No cases are known where a station on continuous operation has encountered this corrosion problem.

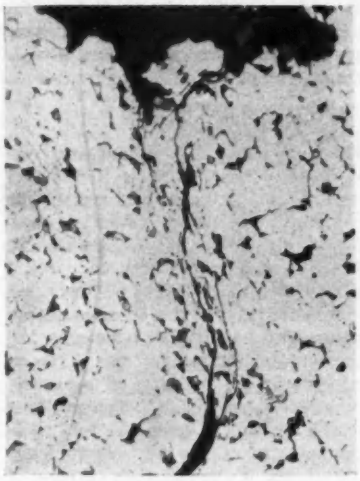


Fig. 23 (left).

Fig. 24 (right).

threshold value (below which no corrosion occurs) was about 22 per cent. nickel.

This form of attack has now been found, in its early stages, in 90/10 cupro nickel tubes where oxidation and flaking of the oxide have been observed. The rate of oxidation appears to be very slow compared with 70/30 or 80/20 cupro nickel and it is estimated that it would take many years before perforation of the tube occurred. The fact that corrosion is occurring, however, disproves the original theory that immunity from this form of corrosion could be obtained by reducing the nickel

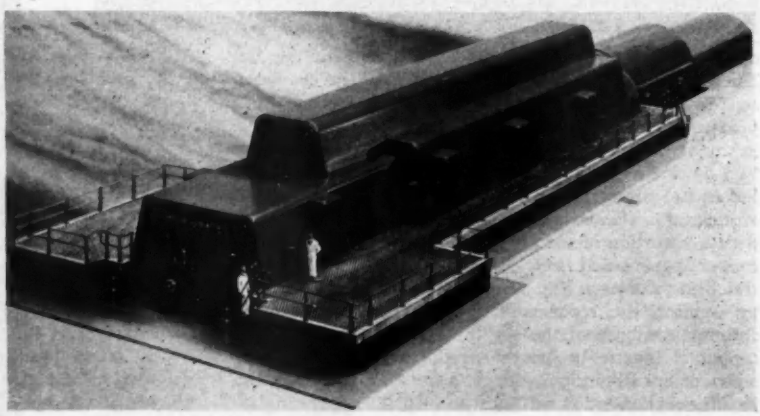
Conclusion

These notes are far from complete in listing and illustrating the many forms of metal failure that occur in service, but they may be found useful in helping to identify the more common types of failure. The author extends his thanks to Mr. P. J. Mitchell and Mr. S. E. Sumner for their assistance in preparing the illustrations reproduced herewith and to the Regional Director of the North Western Region of the Central Electricity Generating Board for granting permission for the publication of this article.

500-MW TURBO-GENERATORS FOR THE C.E.G.B.

We have received from C. A. Parsons & Co. Ltd., Newcastle upon Tyne, some design information concerning the four 500-MW turbo-generator sets which this company is to supply to the Central Electricity Generating Board, as mentioned in our issue of April, 1961. A photograph of a model of one of the sets as viewed from the steam end, is reproduced herewith, to give an impression of the external appearance of the machine. This new order, valued at £13 million, makes a total of six machines of this capacity, and over, to be ordered from the company. Each of the four sets will consist of a single line of tandem compound turbines, operating with steam at a pressure of 2,300 lb./sq. in., 1,050 deg. F. temperature, with reheating to 1,050 deg. F., and driving a hydrogen/liquid-cooled 500-MW generator at 3,000 r.p.m.

From the exhaust of the h.p. turbine, the steam will be reheated and passed to a double-flow i.p. turbine. On leaving this turbine, the steam will complete final expansion through the double-flow l.p. turbines. The h.p. cylinder will be of double-casing construction, whilst the i.p. cylinder will have a partial double-casing. Each of the l.p. cylinders will comprise an outer fabricated shell and cast inner blade carrier. Cascades will be fitted in the exhausts of each l.p. cylinder. A hollow con-



Photograph of model of one of four 500-MW single-line turbo-generator sets recently ordered by the C.E.G.B. from C. A. Parsons & Co. Ltd.

struction of both the h.p. and i.p. turbine shafts will be used to obtain a thermal inertia comparable with that of the casings, to assist in rapid starting and loading.

Two steam-chests, each containing two emergency stop-valves and two governor valves will be arranged one on either side of the h.p. turbine. Intercept valves will be fitted in the steam lines between the reheater and i.p. turbine, with reheat emergency stop-valves as an additional safeguard. The intercept and emergency stop-valves will be housed in external steam-chests, one on either side of the h.p. turbine. Governors housed in the h.p. turbine outer-end pedestal will control the valves by oil relays arranged at the side of each steam chest. Seven stages of feed-heating by steam bled from the machine will be employed, the feedwater being heated to a final temperature of 485 deg. F. at full load.

Each generator will have a rating of 588-MVA, at 0.85 p.f. generating at 22 kV. The rotors will be direct-cooled, operating in hydrogen with a pressure range of 45 to 60 lb./sq. in. Direct-cooled windings will be employed on the stators, the cooling being effected by means of demineralised water.

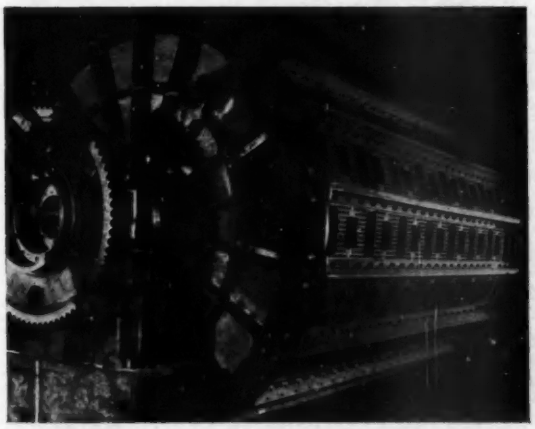
With these methods of direct-cooling for both rotor and stator windings, together with other developments in design, it is possible to obtain outputs of 500-MW from a frame size within the limits imposed by transport.

In their general construction, both rotor and stator follow normal practice. The stators will be of two-part construction, comprising an inner and an outer casing; the inner will carry the stator core and windings and the outer the hydrogen-coolers. The rotors will be single-piece forgings, with cooling of the windings by means of sub-slots machined below the main winding slots and fed with hydrogen at each end. At intervals along the coil will be radial ventilating slots which will exhaust through the retaining wedges into the air-gap. Fans mounted at each end of the rotor body will circulate the hydrogen through the rotor and stator ventilating passages, and then through the coolers before recirculation. Excitation for each generator will be provided by a direct-driven a.c. exciter feeding the main generator rotor through a silicon rectifier.

FOSTER WHEELER HOUSE

Foster Wheeler Limited recently moved into new offices in London—Foster Wheeler House, Chapel Street, London, N.W.1. A photograph of the new offices is reproduced herewith. The move has been necessary in that increased commitments have demanded the expansion of all departments embracing the design, engineering, fabrication and construction of the company's wide range of products. The Foster Wheeler organisation, which is International in its scope, has had over 50 years' experience in designing and building industrial equipment in many parts of the world. Its extensive resources are available to industry, backed by knowledge gained in successful achievement. Foster Wheeler power plants are known in every industrial country, and the company's marine equipment is to be found in the naval and merchant fleets of many nations. Its petroleum-refining technique and petrochemical processes are widely used throughout the world, while the Foster Wheeler group has had considerable success in specially designed units. The company's works, situated at Egham, Surrey, are equipped with a modern machine shop, assembly and fitting shops; the manufacture and assembly of various equipment carried out at these works including:—air-heaters, package steam and waste-heat type boilers, calorifiers, condensers, coolers, desuperheaters, evaporators, heat-exchangers, pressure-vessels, steam purifiers and vacuum refrigeration plants. In addition to the manufacture and assembly of the above mentioned products, the works specialises in the fabrication of various parts for site-erected equipment including:—boiler and furnace tubes, superheater tubes, headers (waterwall and superheater), condenser type superheat controllers, components for distillation towers, etc.

G.E.C. BRADFORD BREAKER FOR COKING PLANT



Under construction in the Fraser & Chalmers engineering works of The General Electric Co. Ltd., at Erith, is a 14 ft. dia. × 22 ft. long Pennsylvania spider-mounted Bradford breaker. It will be used for crushing coal in the coking plant being built at the new Spencer works of Richard Thomas & Baldwins Limited, Llanwern, near Newport, and is being supplied by G.E.C. through Mitchell Engineering Limited. The machine, which is the largest of the Bradford breaker range, will act as a primary crusher, receiving run-of-mine coal up to 12 in., at a rate of 600 tons/hr., and giving a product size of $-1\frac{1}{2}$ in. Coal enters one end of the slowly-rotating breaker, and the oversize is lifted on radial shelves before dropping on to the heavy-perforated screen-plates. Gravity impact breaks the coal, and on reaching the desired product size it is immediately discharged through the plates. Any refuse not broken is passed through the machine and rejected at the far end. This size of machine is claimed to be capable of accepting 30 in. lumps of coal, and its capacity can be increased by fitting a hammermill rotor inside the breaker at the discharge end. Suitable internal adjustments can be made to suit the type of coal being fed into the breaker, and the screen plates may be easily changed to obtain a different product size.

BOILER PLANT FOR B.M.C. FACTORY

A contract for the supply of a complete boiler-house and ancillary equipment was placed recently with Cochran & Co. (Annan) Ltd., by The Industrial Management Corporation for Scotland, for the new B.M.C. factory at Bathgate. Five of the largest coal-fired Cochran Sinupac high-pressure, hot-water boilers will be installed, plus other equipment. The plant as a whole has been laid out in close collaboration with the National Coal Board, and represents a further major break-through into industry by coal-fired appliances, in view of the trend that existed with oil-fired equipment. There is no doubt that the placing of this contract with Cochrans will give great heart to Scotland, particularly as the country's economy is very closely tied up with coal. The boilers will have a shell diameter of 12 ft. 9 in. and will be suitable for maximum pressure of 180 lb./sq. in. with external nitrogen pressurisation, and in addition they will contain certain novel features. The water-space will be completely occupied by smoke-tubes, thus increasing the heating surface and minimising the draught loss, and, at the same time minimising the water capacity of the boiler, making for quicker start-up, thus increasing the flexibility of the plant. Furthermore, the return water will be brought down to the bottom of the boiler and discharged through mixing jets to avoid temperature stratification.

Generally speaking, this can be considered a large installation of shell-type boilers for heating by high-pressure hot-water and will, it is claimed, have definite advantages to offer over the traditional oil-fired boilers. The "Sinupac" boilers are compact and since the gases are carried through the smokebox at high velocity, the heat-transfer co-efficients are high, enabling excellent thermal efficiency to be obtained.

Chain grate stokers of the latest type and design are being used as a result of collaboration between Cochran & Co. (Annan) Ltd., and James Hodgkinson (Salford) Limited. A particular feature of these stokers are the arrangements made to secure optimum air distribution through the fuel-bed. The stokers will be controlled automatically by means of Unitherm automatic combustion control equipment. Continuous ash-extraction equipment will be supplied, discharging directly into an ash-conveyor, which will also receive the discharge from the grit-arrestors. The combustion chambers of the boilers will be cleaned by means of vacuum equipment.

Included in the boiler-house will be a coal- and ash-handling plant of 40 tons/hr. capacity, a motorised dragline, and automatic tempering of the incoming coal. The coal will be untreated smalls, containing over 40 per cent. fines. Each boiler will burn approximately 1.8 tons/hr., and even on this low-grade coal, the efficiency will, it is estimated, be approximately 80 per cent. on the gross calorific value.

POWER STATION EFFICIENCES

A reduction in fuel costs equivalent to nearly £3 million, resulted during 1960, from the improved thermal and operating efficiency of Central Electricity Generating Board power stations. The overall average thermal efficiency during the year was 26.71 per cent., as compared with 26.36 per cent. for the previous year. Almost one-third of the 102,891 million kWh sent out from these stations was supplied by the twenty most efficient stations. These had an average efficiency of 31.49 per cent., their individual efficiency percentages being:—

Station	C.E.G.B. Division	Thermal Efficiency (per cent.)
Blyth "A"	North Eastern	34.28
Agecroft "C"	North Western	34.14
High Marnham	East Midlands	33.20
Drakelow "B"	" "	33.03
Castle Donington	" "	32.70
Ferrybridge "B"	Yorkshire	32.60
Staythorpe "B"	East Midlands	32.35
Willington "A"	" "	31.79
Northfleet	South Eastern	31.30
Tilbury "A"	Eastern	30.90
Belvedere (L.P.)	South Eastern	30.77
Marchwood	Southern	30.75
Drakelow "A"	East Midlands	30.71
Aberthaw	South Wales	30.63
Rogerstone	" "	30.37
South Denes	Eastern	30.25
Meaford "B"	Midlands	30.15
Stella South	North Eastern	30.14
Wakefield "B"	Yorkshire	30.14
Stourport "B," (H.P.)	Midlands	30.04

Coal Tar Fuels

At a reception held recently at the Savoy Hotel, London, by **The Association of Tar Distillers,** The Rt. Hon. Richard Wood, M.P., Minister of Power, introduced the revised edition of the Association's publication "Coal Tar Fuels." It will be appreciated that coal tar fuels make an important contribution to the fuel resources of the country in these days of increased usage of liquid fuels. They are derived from British coals, and have the advantage of a low sulphur content and high flame emissivity. The authors of this new and completely rewritten edition of the book "Coal Tar Fuels" are experts in the field of liquid fuels, especially of coal tar fuels, and they have been closely associated with the development of the fuels in recent years. The first chapter describes briefly the production of coal tar in the coal carbonisation process, then surveys generally the technique of coal tar distillation to give the valuable products and finally shows how the different coal tar fuels are prepared. Chapter 2 concerns the composition and properties of the fuels, and emphasises particularly the importance of the carbon/hydrogen ratio and low sulphur content. In discussing the viscosity, it is pointed out that the fuels are, in fact, designated according to the temperature (deg. F.) at which the fuels reach viscosities suitable for atomisation. The combustion process is considered in Chapter 3, showing the theoretical amounts of air required for combustion of coal tar fuels, and the products resulting. Some interesting information follows on how a study of flame shape and flow patterns can be of practical use in improving furnace processes. Chapter 4 is of considerable value to chemical engineers concerned with designing the equipment for storing and handling the fuels. Several new nomograms have been worked out based on practical data. The many types of burners, pumps, valves, heaters and other auxiliary plant equipment recommended are described in Chapter 5. Many illustrations and drawings are provided by the courtesy of manufacturers. In the final Chapter on "Applications," the suitability of coal tar fuels for open-hearth furnaces and other types of metallurgical plant, and for boiler plant and other purposes is demonstrated. The advantages originating from the low sulphur content and high flame emissivity in the particular use and the influence on fuel efficiency are stressed.

"Coal Tar Fuels," 2nd edition, is published by the **Association of Tar Distillers,** 9, Harley Street, London, W.1, price one guinea.

THE LATE MR. ARTHUR ARNOLD

It is with regret that we record the sudden death on April 6th, of Mr. Arthur Arnold, A.M.I.Mech.E., A.M.I.E.E., M.I.Plant E., F.Inst.F., editor of our contemporary, "Power & Works Engineering." Mr. Arnold, who was 69, and had planned to retire this summer, was the senior editor on the staff of Tothill Press Limited, in respect both of age and of length of service. He joined the company in 1919 as assistant editor of *The Power User* and became editor almost immediately. As the editorial policy developed, the name of the journal was changed successively to *The Power Engineer*, *The Power and Works Engineer*, and finally to its present title. This journal has thus had the benefit of 42 years of uninterrupted editorial control. Mr. Arnold was born at Lymington, Hants., educated at Southampton Grammar School, and became an articled pupil first at Siemens Brothers Dynamo Works, Southampton, and then at Weymouth Corporation Electricity Works. Subsequently he held posts as charge engineer with Weymouth Corporation, Watford Electricity Works, North Metropolitan Electric Power Supply Company, Walthamstow U.D.C., County of London Electric Supply Company, Luton Corporation, and Yorkshire Electric Power Company. He also worked for a time in the turbine shops of Richardsons Westgarth, West Hartlepool. During the 1914-18 war he held a temporary commission as Engineer Lieutenant on board H.M.S. *Valiant*, returning thereafter to the Yorkshire Electric Power Company for a short time before taking up his editorial appointment.

LEADERS IN ALL FIELDS . . .

More and more steam users are installing Hamworthy oil-burners, both Pressure Jet and Rotary, to fire steam raising plant from the largest water tube boilers to small shell boilers.

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RECENT Equipment AND Accessories

New "Coltomat" packaged boilers

British designed throughout, and incorporating no foreign patents, a new series of oil-fired packaged type boilers, which, it is claimed, are built to generate steam efficiently and economically for space-heating or process-plant, is now being manufactured by Walter W. Coltman & Co. (Boilers) Ltd. Known as the "Coltomat" Models 70, 150 (Fig. 1) and 250, these packaged steam boilers are self-contained on a rigid base-frame. No special foundations are necessary for these boilers as each model is delivered as a self-contained unit which, when connected to the requisite electrical, fuel and water supplies, is ready for operation.

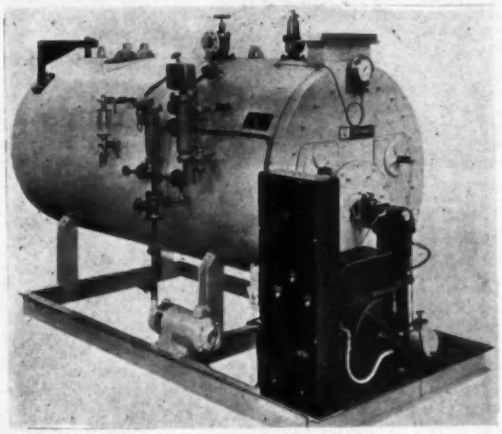
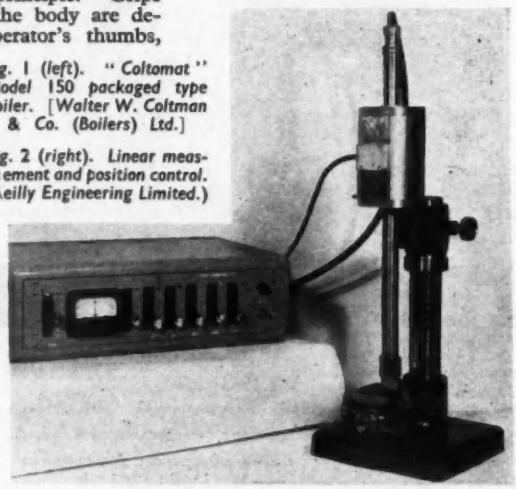


Fig. 1 (left). "Coltomat" Model 150 packaged type boiler. [Walter W. Coltman & Co. (Boilers) Ltd.]

Fig. 2 (right). Linear measurement and position control. (Reilly Engineering Limited.)



Consumption claimed at full-load for the three models is 5, 11 and 18 gal./hr. respectively—this is claimed to be equivalent to 80 per cent. thermal efficiency. A simple sequence, incorporating safety controls, means that the unit will operate without any need for attention, except daily routine checks. The "Coltomat" boiler shell is of riveted and welded construction, the fire tubes being expanded into the tube-plates whilst the set tubes are screwed and expanded. The boiler is fitted with a specially-developed fully-automatic burner of the combined air-blast/pressure-jet atomising type, and this is equipped with electric ignition. All boilers are pressure tested hydraulically at the maker's works, a test certificate being issued with each boiler. [*Walter W. Coltman & Co. (Boilers) Ltd., Loughborough, Leics.*]

Portable hardness tester

Smiths Industrial Division have become sole U.K. distributors of a British invention—a portable hardness tester. This hardness tester which weighs only 3 lb., is claimed to be the only portable instrument of its type, embracing all recognised hardness value scales—V.P.N., Brinell, and Rockwell "C." It covers full B.S.I. 869 specification range of hardness values. A bench-type version is also available; weighing only 28 lb., it can be used as a fixture or can be transported from one department of a works to another. The action of the tester is comparable to the Rockwell principle. Grips on either side of the body are depressed by the operator's thumbs, this action lowering a diamond indentor from its otherwise retracted position and bringing it into contact with the material under test. Further depression causes the diamond point to penetrate (to a maximum of 0.005 in., and during transmission of this vertical movement to linear movement of the pointer, the former is magnified in the ratio of 1,200 : 1. Hardness scales on the large, safety-glass protected dial are in distinctive colours to allow for easy reading; while sturdily constructed to protect its sensitive mechanism, the instrument is nevertheless light and easy to handle. The hardness tester which was invented and developed by J. O. Deakin & Co. Ltd., Tavistock, Devon, is well-finished and heavily plated, and is supplied in a wooden carrying case. (*Smiths Industrial Division, Kelvin House, Wembley Park Drive, Wembley, Middx.*)

New linear measurement and position control

A new system of high-accuracy linear measurement and position-control (Fig. 2) has been developed by Reilly Engineering Ltd. This system employs compact transducers designed to measure linear displacement with extreme accuracy in conjunction with a null indicator. The principle of operation combines the functions of length, reference bars and the a.c. bridge and as there are no moving parts other than the transducer head, sliding on its shaft. The instruments are claimed to be completely reliable and trouble free in operation. The position of the transducer head is ascertained in the case of the hand-set instrument by adjusting a number of decade switches until the meter reads zero; in the 10-in. transducer, for example, five switches are adjusted, the first one having 10 steps of 1 in., the second having 10 steps of 0.1 in., and so on to the last which has 10 steps of 0.0001 in. each. The whole operation takes approximately 10 sec., and the accuracy achieved in this case may be as close as ± 0.00002 in. depending upon the accuracy required, with a repeatability of 0.000005 in. When the instrument is used for inspection purposes, the decade switches adjust themselves automatically as the transducer head is moved to each new position. This is effected in an average time of 1½ sec. The system can be used to facilitate high-speed production in conjunction with

numerous machine tools including milling machines, jig borers, lathes, forging-presses, etc. Developments are in progress for its use on a lathe for screw cutting without a gear-box; any pitch can be set up in a few seconds, a set of decade switches acting as an electronic gear-box. An interesting application is its use as an electronic pantograph with the aid of two transducers moving in step in any desired ratio. In this case, as a photo-electric transducer follows the drawing, its position is being continuously measured by a set of linear transducers by means of which a flame cutter or contour mill can be made to reproduce the drawing in the required ratio. This system operates with equal efficiency when working on an intricate part from a drawing 100 times full-size as when cutting a plate from a 1/10th scale drawing. Various attachments can be used to assist the operation of the transducers, such as a zero offset unit with the aid of which the operator can set a workpiece in a convenient position and make all measurements with reference to the required zero position indicated on the drawing. An indicator lamp unit which displays the measurements made in large figures is also available. The transducers can be supplied in models ranging from a unit which can deal with measurements as large as 500 ft. to one capable of measuring 0.0000001 in. Their simple form of construction which takes advantage of the latest developments in transistors and printed circuits, is claimed to ensure reliability in operation, and also reduces the initial cost of the equipment. (*Reilly Engineering Limited, Forsyth Road, Sheerwater, Woking, Surrey.*)

New Masoneilan control valve

Crosby Valve & Engineering Co. Ltd. recently announced the introduction of a completely new Masoneilan single-seat, heavy-duty globe-valve body, which they claim possesses exceptional flexibility of application. Extra heavy top-guiding of the plug is said to eliminate the need for orthodox bottom-guiding, reducing turbulent flow, and trouble due to any solid particles which may be in suspension. Careful attention to body and port design to give a streamline flow, plus the elimination of the bottom guide permits a greater rate of flow through a given seat diameter. These flow engineering features, it is claimed, enable the new "20,000 Series" valves to have a much greater flow capacity, the capacity being approximately equal to that of the equivalent line-size, double-seat control valve. The new valve is said to withstand considerably greater out-of-balance pressure across the seat compared with that of an orthodox single-seat control-valve and still give tight shut-off and stable throttling control. Another feature of this new valve is that each size of valve is available with a wide range of interchangeable reduced-area plugs and seats for temporary conditions; lower flows, higher pressure-drops, later increased throughput, etc. The "20,000 Series" valves (Fig. 3) are available screwed $\frac{3}{4}$ in. to 2 in., with trim sizes $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{3}{4}$, $1\frac{1}{2}$ and 2 in. Flanged $\frac{3}{4}$ in. to 10 in. with not less than four trim sizes for each line-size valve. Standard materials are:—carbon-steel body, stainless-steel trim, other materials being available

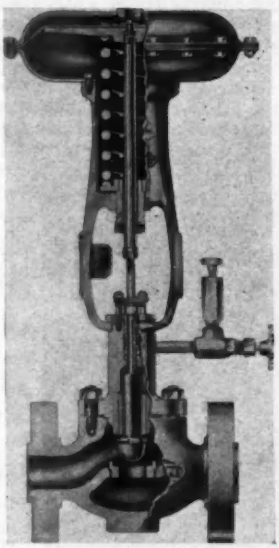


Fig. 3. Masoneilan "20,000 series" control valve. (Crosby Valve & Engineering Co. Ltd.)

to order. It is claimed that by replacing the lower guide by the heavy-duty top guide reduces the possibility of trouble on services involving fluids having solids in suspension, which could be trapped in the normal type of bottom guide. This new valve combines the performance characteristics of an angle-type control-valve with the advantage of the simplified pipework of a straight-through type of body. The combination of these features; high capacity, high permissible pressure-drop, minimum number of working parts in contact with the fluid, and large range of interchangeable trims enables this new valve to suit a wide variety of applications. (*Crosby Valve & Engineering Co. Ltd., Crosby Works, Ealing Road, Alperton, Wembley, Middlesex.*)

Gelled primers in steelwork protection

A substantial saving in the time and labour costs of protecting structural steelwork from corrosion can, it is claimed, be effected by a new painting system developed by John S. Craig & Co. Ltd. Thick film-gelled primers, two coats of which are said to be equal to four or five coats of conventional paints, but which do not sag or "curtain" after application, were introduced by this company at the Scottish Industries Exhibition in September, 1959, after extensive laboratory and raft-exposure tests. At that time, the products were primarily developed for marine requirements, and for the past year they have been subjected to extensive sea trials. In the course of these trials, use of the primers on superstructures gave excellent protection, and this led to development of their use on industrial steel structures, many of which, while being subjected to severe corrosive conditions, are inaccessible except during process shut-down periods. The ability to apply very heavy coats of primer in a short time is obviously important especially where high staging must, of necessity, be erected before the painting can be commenced. Accordingly, several tall steel supporting-structures for tanks and water-coolers at the Dalzell works of Colvilles Limited, were coated with the gelled primers during the works shut-down period a few months ago. Application properties were found to be satisfactory, allowing recoating either "wet on wet," or at 24-hour intervals. Inspections made to date show that durability is excellent in the most severely-exposed conditions, such as being subject to continuous cascades of hot water, or water mist combined with sulphur-containing smokes from adjacent furnace stacks. The advantages in cost, time, and convenience of application have been demonstrated, but the company will not be issuing their detailed assessment of performance until the primers have been on trial for a full 12 months. (*John S. Craig & Co. Ltd., Shieldhall, Glasgow.*)

A new V-link belt

The recent trend in V-belt drives has been towards narrower or smaller endless-belts, capable of transmitting higher horse power. "V-link" belting claims many advantages over solid endless-belts, but there were many practical difficulties in producing a link belt capable of transmitting similar loads to the premium, or wedge-type of endless-belts. Brammer & Co. Ltd. have now developed a "Brammer Plus" link belt which

is the result of much research and experimental work in their own rubber factory. The special rubber sheeting used, is made from a blend of cotton and man-made fibres, vulcanised with special synthetic rubber. The manufacturers claim that this combination results in a belt which is considerably stronger in every way, will transmit greater horse power, give a longer life, and in addition, is heat and oil-resisting. For identification purposes the belt is made in red, and is fitted with studs marked "B," which have colour variation to determine section widths. It is of interest to observe that in addition to the factory in England, from which the manufacturers export to over 70 countries abroad, Brammer V-link belting is also manufactured in factories in the U.S.A. and India. (*Brammer & Co. Ltd., Leeds.*)

"Plisulate Verilite" insulation lining

A castable product with a vermiculite base has been used as an insulation lining for the monolithic refractories in the furnaces of the four Foster Wheeler ESD-type boilers in the new P. & O.-Orient liner *Oriana*. The material, "Plisulate Verilite," is a product of Plibrico Co. Ltd., who designed the special monolithic linings for the furnaces in co-operation with Foster Wheeler Limited and the shipbuilders, Vickers Armstrongs (Engineers) Limited. The four boiler furnaces are each provided with complete Plibrico monolithic linings, (Fig. 4) the front walls being lined with "Plibrico Super X" plastic refractory, and "Plicasto Super" castable refractory being used for the roof, side, and rear furnace walls. The "Plisulate Verilite," containing vermiculite with its special characteristics of thermal insulation, and resilience to thermal and physical shock, is used throughout as a monolithic insulating lining. The furnace hearth is paved with "Plibrico Super X" plastic refractory, again using the "Plisulate Verilite" castable insulation which is said to have proved in service to be capable of withstanding the effects of water-washing. (*Plibrico Co. Ltd., Westmorland Road, London, N.W.9.*)

"Levelrator" continuous level indicator and controller

After extensive field trials in various industries a new instrument known as the "Levelrator" has been released to the industrial market by Thomas Industrial Automation Limited. The manufacturers claim that the "Levelrator" not only gives continuous indication of the contents of silos, tanks, hoppers, etc., but it will also operate visual and/or audible alarms. The equipment uses one electrode only for both continuous measurement and control. Alarm points can be set to operate over the full length of the electrode to suit the particular application. The electrode system can be of the rigid variety for a small vessel, and of the flexible type when the depth of the container exceeds 6 ft. The limitation of length of electrode is really dependent upon the particular application, but electrodes are available up to 60 ft. in length. The high or low-level control points are completely independent of the indicating instrument, and the relays are operated by a specially-designed electronic circuit. The long term stability and reliability of this equipment is exceptionally high, and is claimed to be virtually unaffected by normal mains and temperature fluctuations. The control unit, consisting of a stabilised power supply, alarm relay circuits, and built-in calibrating instruments, is housed in a specially-designed cast-iron or sheet-steel weatherproof case which can be positioned up to 150 ft. from the electrode head unit. The built-in calibrating instrument has a scale length of 2½ in., and this is graded in 2 per cent. divisions and can, if necessary, be used as a local indicator. Remote indicators can be supplied to individual requirements, and sited anywhere on the plant. The "Levelrator" can be supplied in multi-point units which allow centralisation of all the control and indicating meters. Meters can also be supplied for fixing to existing panels and control desks. By the use of the specially-designed electrode systems and by careful positioning of these electrodes in the containers, good accuracies and near linear scales can be achieved. The equipment can be supplied for all standard mains voltages. (*Thomas Industrial Automation Limited, Station Buildings, Altrincham, Cheshire.*)

"Dolphin" range of verticle centrifugal pumps

The above new range of pumps (Fig. 5) has been designed to cover a wide range of duties within a small number of frame sizes and, at the same time, give maximum installation flexibility and maintenance access in a simple robust construction. The pumps were originally designed specifically for marine ducting, such as salt and fresh-water circulation, bilge, ballast, fire, etc., but they are also said to have proved very successful for industrial duties with such fluids as petrol, solvents, light oils, etc. Capacities range from 60-2,000 gal./min. with heads up to 300 ft. It is claimed that the wide performance coverage is achieved with only three frame sizes, and interchange of impellers and diffusers giving any desired operating condition. The need for simplicity has received very careful consideration, and the

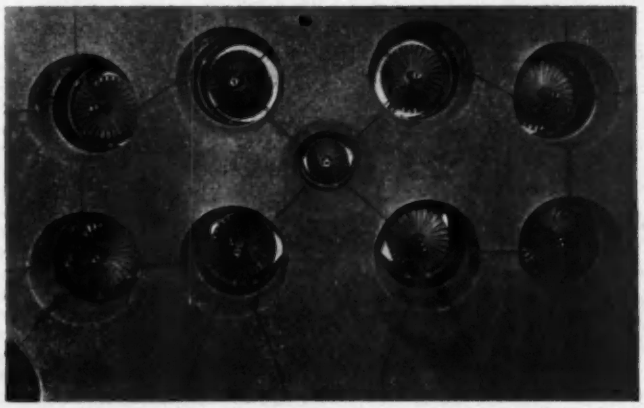


Fig. 4 (left). Plibrico monolithic linings in boiler furnace of the liner Oriana. (Plibrico Co. Ltd.)

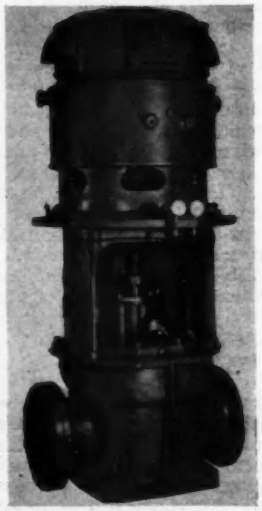


Fig. 5 (right). "Dolphin" vertical centrifugal pump. (Hamworthy Engineering Limited.)

Protectoglo

is the only combustion safeguard relay which can be used with every known rectification type of sensor: electrode, photocell, infra-red, ultra-violet . . . Whatever the type, Protectoglo gives you, in a single box, the basis of a wide variety of safety systems. It provides automatic cut-off on flame failure, push-button reset purge timing. Protectoglo has a fully plug-in chassis and a self-checking circuit to prevent start-up in the unlikely event of a faulty component.

WRITE OR SEND THE COUPON TODAY to
Honeywell Controls Limited
Greenford Middlesex Waxlow 2333

I am interested in PROTECTOGLO —your new combustion safeguard relay. Please send Specification Sheet No. S 1015-2

Name _____

Position _____

Company _____

Address _____

EBHR

Sales Offices in the principal towns and cities in the United Kingdom and throughout the world.

Honeywell

First in Control

SINCE 1885

fact that the makers claim that inexperienced operators can dismantle an entire unit in a matter of minutes, indicates the degree of success achieved. The main casing has two diametrically-opposite suction-flanges to give a choice of connection and allow the single discharge to be brought to the required position. The motor support-pedestal, mounted on top of the casing, has a large opening for easy access to the pump itself and may also be turned to any one of four positions. Thus the pump is not limited to any particular mounting position and can be rotated so that maximum accessibility can be achieved in restricted spaces. The flanges are constructed in such a way that the effect of pipe stress is claimed to have been eliminated. The impeller is supported by a short, heavy-section shaft, running in a single bearing which may be either grease or water-lubricated. Either a soft-packed gland or various types of mechanical seals can be fitted as required. The bearing and shaft can be supplied in special corrosion-resistant materials to suit the pumping medium. A short coupling-spacer, fitted between the motor-coupling and shaft, facilitates dismantling procedure, which is one of the most interesting features of the pump. To remove the complete impeller assembly, it is only necessary to remove the coupling screw, take out the spacer, remove screws from top cover and withdraw the rotating element, complete with top cover, bearing, and gland, from the main casing. Suction and pressure gauges are fitted as standard equipment and self-priming or non-self-priming units can be supplied as required. (*Hamworthy Engineering Limited, Poole, Dorset.*)

Three-point pipe bender

A new British made, 1½ in. capacity, hydraulic three-point bending machine (Fig. 6) has been recently introduced into the Staffa range of pipe, bar, and section-benders. Suitable for use by heating and ventilating engineers, gas and electricity boards, oil, petroleum, refrigeration and general engineers, etc., the machine will bend steam and gas pipes of up to 1½ in. nominal bore. The bender, which has been designated the "B2," and which does not require a bench or stand, consists of a powerful hydraulic pump-ram unit, a forming-head assembly and centre formers for ½-1½ in. nominal bore pipes to B.S.S. 1387. The whole assembly, complete in a wooden case, weighs 110 lb. and a feature of the machine is the angle-of-bend indication-marks cast in one end of the formers, which provide a useful guide during the bending operation. The hydraulic unit is claimed to provide easy and one-handed operation, and to require

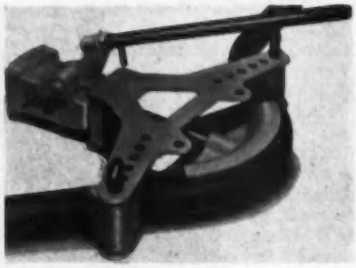


Fig. 6. 1½ in. capacity hydraulic three-point pipe-bending machine. (Chamberlain Industries Limited.)

very little maintenance. The machine is claimed to be much faster than any screw-type bender, and a full 90° bend can be made in 1½ in. pipe in 1 min. (*Chamberlain Industries Limited, Staffa Works, Argall Avenue, Leyton, E.10.*)

Combined involute and helix measuring machines

David Brown have recently added to their range of gear-measuring equipment with the introduction of the No. 18 series combined involute

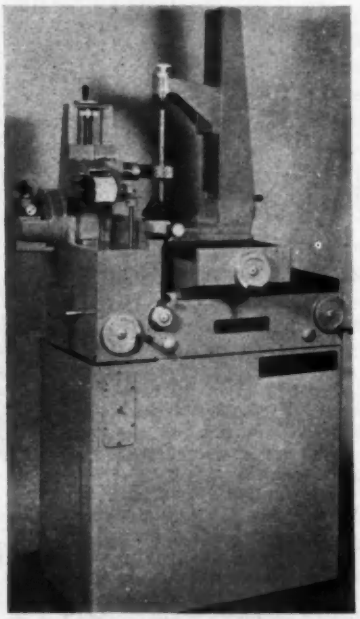


Fig. 7. No. 18 series combined involute and helix measuring machine. (David Brown Industries Limited.)

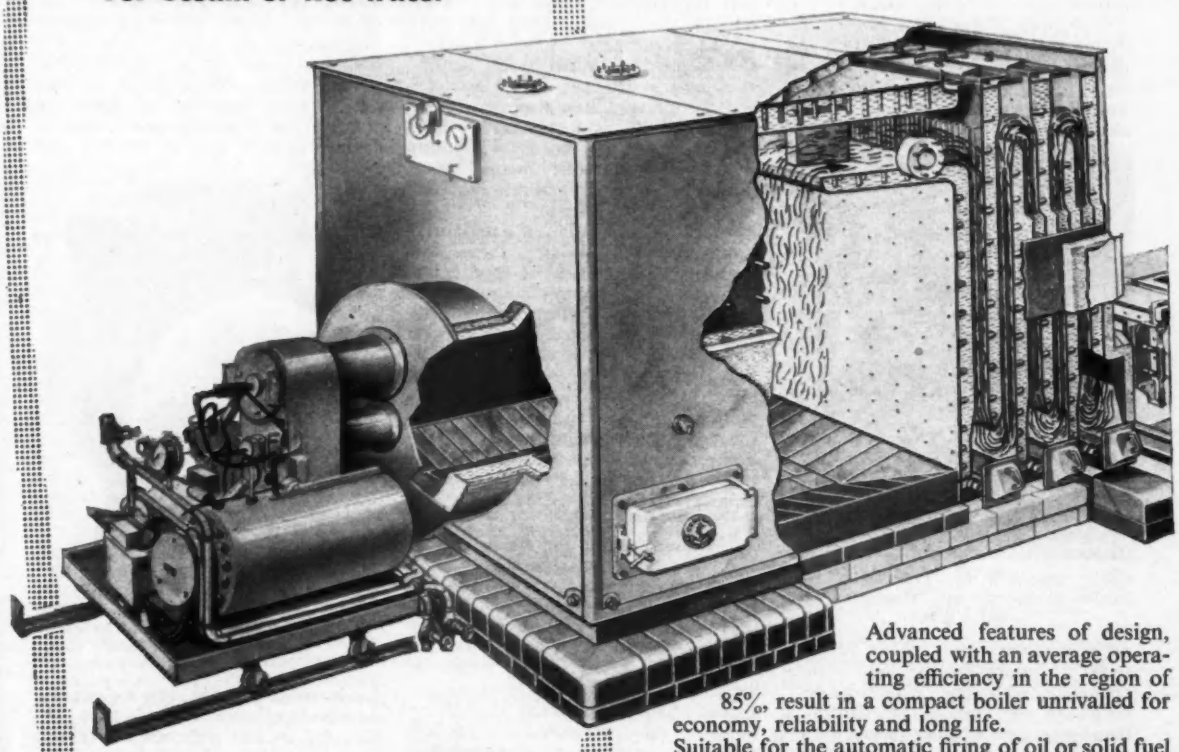
and helix measuring machines. These machines are designed to accommodate spur and helical gears having base-circle diameters ranging from ¾ in. to 18 in. With the centre-locating column in position the machines will admit gears up to 12 in. dia. with 18 in. between centres. Gears up to 18 in. base-circle dia. can be accepted when the centre column is removed. There are two main models in the No. 18 series. The standard machine (the No. 18, Fig. 7) is equipped with the David Brown mechanical recorder, which has a magnification ratio of 500 : 1, and the ratio of graph-length to slide-movement can be varied between 1 : 1 and 3 : 1. There is also a special model (the No. 18T) which incorporates the "Talymin" side-acting gauge head with electronic rectilinear recorder and amplifier, giving magnification ratios ranging from 100x to 5,000x. A gearbox in the recorder allows the ratio, chart-length to length of appropriate slide movement, to be 1 : 1, 2 : 1, or 4 : 1. It is claimed that with either machine, variations in the order of 0.0001 in. can be accurately recorded. The actual procedure for involute testing is simple in operation. With the gauging point of the recorder stylus located exactly above the working face of the straight-edge, the base disc, mounted co-axially with the gear under test, is brought into contact with the straight-edge. Rolling of the base disc along the straight-edge causes the gauging point in contact with the appropriate gear-tooth flank to describe the designed involute curve. If the flank is a true involute a straight-line graph will be recorded. Any deviation from the true involute will be recorded by movement of the pen across the graph paper. The procedure for helix testing is also simple to apply. By combining vertical movement of the stylus with the corresponding vertical movement of the gear the gauging point describes the correct helix. In combining the dual functions of involute and helix testing, these David Brown measuring machines are designed to meet the present-day requirements of gearing manufacturers, and are particularly applicable where gear shaving or gear grinding is applied as a finishing operation. In designing this equipment, regard has been taken of the variety of applications on which the equipment will be used, and the machines are being built to meet all the normal requirements of standards room, inspection, and shop use for the measuring of gear helices and involutes. The earlier model (the No. 18R), a bench type involute measuring machine, continues in production. (*David Brown Industries Limited, Tool Division, Park Works, Huddersfield.*)

High Efficiency Boilers

CENTRAX

GUSTAVSBERGS

For Steam or Hot Water



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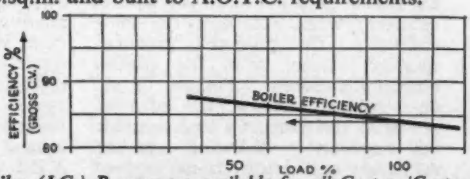
RILEY

(I.C.) BURNERS

Advanced features of design, coupled with an average operating efficiency in the region of 85%, result in a compact boiler unrivalled for economy, reliability and long life.

Suitable for the automatic firing of oil or solid fuel and readily convertible to either. Modern, welded steel plate construction gives low first cost. Ease of access for cleaning produces High Annual Efficiencies, Low Maintenance Costs. Controlled Water circulation obviates the risk of corrosion and thermal shock.

Available in 20 sizes ranging from 2½ million B.T.U/hr. to 12 million B.T.U/hr. at pressures up to 100 lb.sq.in. and built to A.O.T.C. requirements.



Riley (I.C.) Burners are available for all Centrax/Gustavsbergs Boilers and any others with capacities ranging from 5 lb. to 9000 lb. of oil per hour. Centrax/Gustavsbergs Boilers are also available with Riley (I.C.) underfeed stokers.

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New combustion safeguard relay

An improved "Protectoglo" combustion safeguard relay, using the flame-rectification principle, was recently introduced by Honeywell Controls Limited. In one relay, it is claimed, are embodied all the most advanced techniques in this field. These include: a choice of all accepted sensors for all applications without modification, fully plug-in, chassis (Fig. 8) and purge timer, automatic lock-out on unsuccessful ignition start, and a self-checking circuit to prevent start-up if any component becomes faulty or if the sensor already detects flame. The "Protectoglo" system is suitable for monitoring start-up and cut-off for gas-fired or oil-fired ovens, furnaces, etc. The relay itself is designed for use with a variety of sensors: flame electrode, photocell unit, infra-red

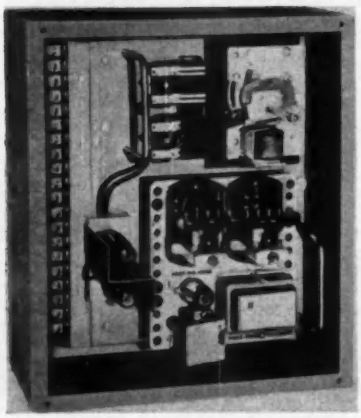


Fig. 8. Chassis of the "Protectoglo" combustion safeguard relay. (Honeywell Controls Limited.)

or ultra-violet types. Two different types of sensor can be used simultaneously with one "Protectoglo" unit. In the case of gas flames, a flame-electrode rectifier would normally be used, the electrode being inserted in the flame, which forms part of the circuit. The flame will act as a rectifier if interposed between two electrodes of unequal area; the burner, or ground electrode when used, will generally have an area of contact many times that of the flame electrode. For oil flames a photocell rectifier is generally sighted onto the flame. The photocell is a natural rectifier; when light from the flame strikes it, the photocell produces rectified current from the applied alternating current. For gas or oil, or combined flames, an infra-red sensor in the form of a lead-sulphide cell responds to pulsating infra-red radiations and unidirectional current is produced by means of an adaptor circuit. Another, more unusual sensor is the ultra-violet detector, which responds only to the ultra-violet light present in the flame. Typical uses of this detector would be dual-fuel installations, high-intensity gas flames, exothermic gas generators, etc. When flame is present, rectified current is fed to the "Protectoglo" relay into one grid of a double-triode electronic tube. The triodes are connected so that the output current will energise the control relay. On flame-failure, no rectified current can be produced, the tube output current will drop to zero, and the control relays will "drop out." The self-checking safe-start circuit in the relay includes a safety switch and a manual reset button. If a fault is detected during start-up and the safety switch goes into safety position, the system cannot be started until the unsafe condition is corrected and the manual reset button actuated. When it is required to prevent any attempt to start the burner until expiration of a measured time interval, during which the combustion space may be thoroughly purged of any accumulation of unburned fuel, a purge timer is supplied. This timer is located in the upper right-hand corner of the relay. The purge timer is fully adjustable from 2 to 15 min. or alternatively 4 to 30 min. At the end of the purge timing period, an external signal-light indicates that the burner may be started. (*Honeywell Controls Limited, Greenford, Middlesex.*)

A.E.I. switchgear for Australia

A contract for switchgear has recently been placed with Australian Electrical Industries Pty. Limited (the Australian Company of A.E.I.) by the Electricity Commission of New South Wales. The order is for five air-blast circuit breakers for a new 330-kV substation at Sydney South, and represents a further step in the development of the 330-kV transmission system in N.S.W. Sydney South will be the first of a number of large 330-kV substations that are planned to supply Sydney Metropolitan Area with power from generating stations in the coalfield area, and from the Snowy Mountains Authority. The five circuit breakers will be manufactured by A.E.I. Switchgear Division; they will be rated at 330-kV, 10,000-MVA, and three of the units will be arranged for single-phase and three-phase auto-reclosing. A.E.I. supplied the first 330-kV air-blast circuit breakers to Australia, and the present order brings the total of such units from A.E.I. for Australia to 23. Previous orders were for Tumut 1 generating station and its extensions, and Tumut 2 generating station (Snowy Mountains Authority); Yass switching station and its extensions (Electricity Commission, N.S.W.); and Yallourn generating station (State Electricity Commission, Victoria). The first units were commissioned in 1959 at Tumut 1 and Yass. (*A.E.I. Limited, Moseley Road Works, Trafford Park, Manchester, 17.*)

New flow-indicator

Claimed to be suitable for use on pressure lines, where flow is either horizontal or vertical, the Model 112 vane-type flow-indicator (Fig. 9) shows the approximate proportion of full flow. If required, a fractional scale can be incorporated as an extra. Observation of the clarity and condition of liquid is possible, and the indicator is said to operate equally well on upward and

Fig. 9. Model 112 vane-type flow indicator. (Suba Hydraulics Limited.)

downward flow. Six sizes are obtainable to fit pipes from $\frac{3}{4}$ in. to $2\frac{1}{2}$ in. dia., the overall dimensions ranging from $4\frac{1}{2}$ in. long × $1\frac{13}{16}$ in. to 6 in. long × 3 in. The unit is constructed of bronze, and is pressure-tested to 100 lb./sq. in. The inlet and outlet connections are threaded to the relevant B.S.P. size. Variations in construction to suit individual requirements can be supplied on request. (*Suba Hydraulics Limited, Limes Place, Limes Road, West Croydon, Surrey.*)

Steelmaking plant for Australia

Davy-Ashmore Limited recently announced that their subsidiary, Davy and United Engineering Co. Ltd., has received an order worth approximately £300,000 from The Broken Hill Proprietary Co. Ltd., for the

design and supply of two 200-ton basic oxygen converter furnaces. These furnaces will be installed in the Newcastle Works, New South Wales, of the Broken Hill Proprietary Co. Ltd. They will be manufactured in the Stockton Works of Ashmore, Benson, Pease & Co. Ltd., who, in addition to having extensive workshops ideally suited for the purpose, have an agreement with Pennsylvania Engineering Corporation, U.S.A., which gives access to their engineering and design experience in the oxygen converter field. The Davy-Ashmore companies have a long experience of converter furnace design. In recent years they have also systematically developed resources for the building of oxygen steel-making plant to the point where a complete design and manufacturing organisation now exists in Britain for this type of plant, the use of which is being rapidly expanded throughout the world. (*Davy & United Engineering Co. Ltd., Darnall Works, Sheffield, 9.*)

A new F.H.P. servo motor and motor generator leaflet has just been published by **Evershed and Vignoles Limited,** giving brief details of the very extensive range of Evershed motors now available. This includes a.c. and d.c. servo motors and motor generators; special purpose motors; tacho-generators; gearheads and torque transmission units as well as amplifiers and power units. Copies are freely available on request to The Public Relations Department, Evershed and Vignoles Limited, Acton Lane, Chiswick, W.4, quoting ES.343.

* * *

The full range of ring balance meters produced by **Hagan Controls Limited** for measuring and recording fuel flow is described and illustrated in a new brochure (H.C. 401) obtainable from the company (a member of the Plessey Group) at 14, Grosvenor Place, London, S.W.1. Diagrams showing suggested installation details are included.

* * *

It is with regret that we record the death recently of **Mr. William Herbert Apthorpe,** M.I.E.E., of the Cambridge Instrument Co. Ltd. Mr. Apthorpe, who joined the company in 1900, left some seven years later to gain further experience with Messrs. Clarke & Fisher and R. W. Paul—later acting as assistant to Professor Donnon, at Liverpool University. Mr. Apthorpe returned to the Cambridge company in 1914 to take charge of the Testing Department; and when Mr. Paul's business was taken over by the company in 1919, he was appointed manager of the London factory. Mr. Apthorpe became a director of the Cambridge company in 1925, and was in succession, director of production, joint managing director and managing director. He retired from executive duties at the end of 1957, but had continued as deputy-chairman.

* * *

After 41 years' service, **Mr. Charles Grad,** A.C.G.I., A.E.I. university liaison officer and consultant to Associated Electrical Industries (Rugby) Limited, retired recently. Until the end of 1959 he was manager of the company's Education Department at Rugby.

* * *

Dr. L. R. Blake, Ph.D., B.Sc.(Hons.)-Eng., A.M.I.E.E., has been appointed to the new post of director of engineering at Brush and has joined the board as an executive director. Dr. Blake was head of the Electrical Section Research Laboratory of B.T.H. Rugby from 1949 to 1956, when he joined the United Kingdom Atomic Energy Authority. His position prior to joining Brush was fast reactor technology manager at Dounreay, Caithness, Scotland.

Birmingham Engineering and Building Centre

The Birmingham Exchange and Engineering Centre, founded 100 years ago as the Birmingham Metal Exchange, will henceforth be known as the Engineering and Building Centre, Birmingham. The last annual meeting of the Exchange and Engineering Centre was held on March 9th. Before the end of this year, the Engineering and Building Centre will be installed in its new permanent exhibition hall at the former Masonic Temple in Broad Street, Birmingham. Since 1954, the Centre has been developed as a permanent exhibition for Britain's engineering industry, and it has also been responsible for organising joint engineering displays at many overseas trade fairs. In future, it will provide ample exhibition space and informative services for the building as well as the engineering industries. The Masonic Temple has space for nearly 300 engineering and 300 building exhibits. The Centre is non-profit-making.

* * *

The Holset Engineering Co. Ltd., Turnbridge, Huddersfield, announces the following recent appointments:— **Mr. R. B. Hesselden,** A.M.I.Mech.E., as a director of the company, and **Mr. R. Barr,** A.M.I.Mech.E., etc., as works manager. Mr. Hesselden, who had been works manager since the company was formed in April, 1952, joined W. C. Holmes & Co. Ltd., in May, 1949. At this time, experimental work was being carried out on a range of flexible couplings and torsional vibration dampers, when the Holset Engineering Co. Ltd. was formed to undertake the manufacture and marketing of these products.

* * *

Mr. St. John de H. Elstub, C.B.E., has been appointed chairman of the Metals Division of Imperial Chemical Industries Limited, in succession to **Mr. M. J. S. Clapham,** who has joined the company's main board as an Overseas Director. After wartime service with the Royal Air Force, Mr. Elstub rejoined I.C.I. in 1947 as a deputy chief engineer of the Metals Division. He was appointed to the Division Board in 1951 as director in charge of metal production, but later in the same year was seconded as director in charge of Summerfield Research Station, the rocket research establishment managed by I.C.I. Metals Division for the Ministry of Aviation. He resumed full-time duties as metal production director of I.C.I. Metals Division in 1952, and was appointed joint managing director in 1957. He was awarded the C.B.E. in the 1954 New Year's Honours for his contributions to rocket technology.

Orders have been placed with the Heating and Ventilating Division of **Sulzer Bros. (London) Limited** for air-conditioning and heating schemes, as part of the £50 million development programme of Colvilles Limited at Ravenscraig and Gartcosh, Lanarkshire. The plan for building a semi-continuous hot strip mill, together with additional steel and iron capacity at Ravenscraig also includes a large sales office building which will be Sulzer air-conditioned; while at Gartcosh the cold reduction mill under construction will have Sulzer high-pressure radiant strip heating equipment. These orders for Sulzer equipment amount to £187,000. For the 2,000 ft. long cold reduction mill at Gartcosh, Sulzer radiant strip heating will be used. Supplied by high-pressure hot water from a boiler plant which also provides steam for process work, the radiant strip heaters are mounted 55 ft. high in order to clear cranes, and afford a clear production floor space. This type of heating gives comfort level with economy of running for a mill of this size. The building has a volume of 30,000,000 cu. ft. and the heating capacity of the radiant strip is some 16,000,000 B.Th.U. to provide a normal temperature of 55 deg. F. The boilers installed will be Marshall & Anderson "Economic" type having an output of 75,000 lb./hr., with a normal working pressure of 100 lb./sq. in. One of the three boilers is intended to serve the heating load via a Cascade heater. The high-pressure hot-water circulating pumps will also be of Sulzer manufacture.

* * *

The Electrical Research Association announces that **Mr. James R. Beard,** C.B.E., Hon.M.I.E.E., is to be its next president. Mr. Beard is the senior partner in Merz and McLellan, consulting engineers, and is known internationally for his work in the electrical field. He was closely associated with the design and construction of the National Grid System and the Scottish hydro-electric schemes, and numerous electric power supply and traction schemes in Great Britain, South Africa, India and elsewhere. Mr. Beard was president of the Institution of Electrical Engineers, 1940-41, and was subsequently elected as honorary member. He was also president of the British Electrical Power Convention, 1953-54; chairman of the Association of Consulting Engineers, 1945-46; president of the Association of Supervising Electrical Engineers, 1937-39; chairman of the Council for Codes of Practice for Buildings, Construction and Engineering Services, 1947-49. He was also a member of the Engineering Advisory Committee of the War Cabinet, 1941-45.

OVERSEAS Steam Engineering Practice

Abridgments of recent articles in the colonial and foreign technical press, concerning design and progress in the technique of steam generation and power plant equipment

Effects of condensing water on rivers

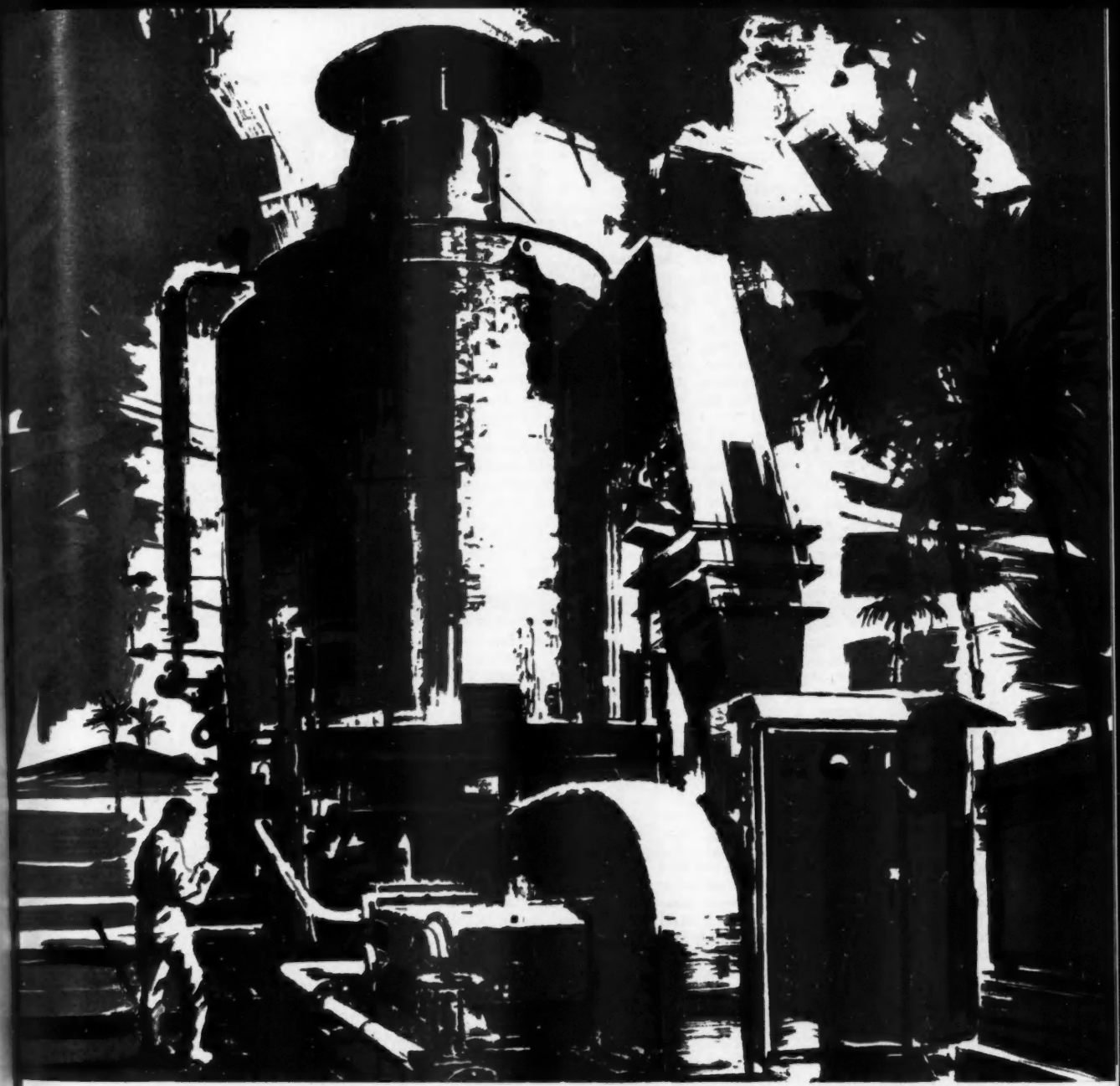
Thermal loading of natural water-ways by steam-power-plant discharge is receiving great attention by many segments of society—technical, political and sporting. Lehigh University's Institute of Research recently conducted some tests along the Delaware River downstream from Pennsylvania Light and Power Company's Martins Creek Plant, and these brought to light many interesting facts and provided some useful data. The test site was ideal since the Delaware river is free of industrial contaminants at this point. Temperature traverses showed that 4,500-ft. downstream the surface water temperatures had returned to normal. The station discharge lies on the river surface, extending not more than 2½-ft. down, thus 85 per cent. of river flow is unaffected. Effect on plant life was noticeable only 1,500-ft. downstream from the station discharge and on the near shore only, no effect being found elsewhere along the river banks. During cold weather the best fishing in the river is just below station discharge. But during summer months, fish tend to avoid a triangular area starting at the point of discharge. They are found in cooler waters outside this triangle. Tests showed no indication of fish being killed by the power plant. (*Power*, Vol. 105, No. 4, April, 1961, p. 94.)

Centrifugal air compressors in large generating stations

Compressed air at various pressures is used throughout modern steam-power plants for general services, instruments and controls and sometimes for soot-blowing requirements. In the past, the air-compressors used have been of the rotary or reciprocating type; only recently have centrifugal compressors begun to be used. The centrifugal compressor is basically a continuous-duty machine whilst soot-blowing and other air requirements are intermittent. Also, centrifugal compressors have been relatively inefficient when compared to reciprocating machines of the same rating in the past. The largest boilers have so many sequenced blowers that soot-blowing is almost a continuous process. With proper selection, a centrifugal compressor to furnish soot-blowing air can be designed for continuous operation. Rotary motion as opposed to reciprocation minimises vibration problems and foundations needed, while floor space requirements are lower than for reciprocating compressors of the same rating. Centrifugal compressors deliver oil-free air—avoiding explosion hazards in air-piping systems, and eliminating severe maintenance problems in instrument-air equipment. Typical multi-stage centrifugal compressors are made up of a forged alloy-steel shaft having multiple impellers and rotating in a horizontally-split casing. Casings are of high-tensile cast-iron or steel, while the impellers are low-alloy forged-steel, welded or riveted together. Compression is achieved in successive steps of adding velocity to the air at each impeller, and converting this energy to pressure in interstage volutes or diffusers, while the overall compression-ratio is varied by changing the number of stages. Pressures needed in most central-station applications, 250 to 300 lb./sq. in. require two separate multi-stage machines in series, driven in tandem by an electric motor through speed-increasing gears. Centrifugal-compressor designs for central-station application are not static; equipment being offered today differs in arrangement from most machines currently in use. While two machines or casings in tandem are still being used, the first, low-pressure casing will probably have three stages of intercooling. The first machine then is a standard 100 lb./sq. in. design and the additional intercooling increases its efficiency considerably. An external tubular heat-exchanger is used between the two casings in an arrangement similar to the older one, permitting a conventional multi-stage compressor to raise air pressure to the required 250 to 300 lb./sq. in. with no intercooling. Air for soot-blowing purposes is used as discharged, while plant air goes through an aftercooler before entering the distribution system. A typical centrifugal compressor is now serving a 2-million-lb./hr. capacity boiler, and has a discharge pressure of 300 to 350 lb./sq. in. It provides soot-blowing air at full discharge pressure, and instrument, control and plant-service air for pneumatic tools and hoists can be taken from an intermediate stage at 100 lb./sq. in. Alternatively, service air can be reduced from full discharge pressure. Larger units of 500-MW and upwards are unquestionably suitable for centrifugal compressors, which will become a more familiar sight in the large central power stations of the future, providing all station air-service needs. (*Power*, Vol. 105, No. 4, April, 1961, p. 82.)

Humboldt Bay nuclear power unit

Pacific Gas & Electric Company's Humboldt Bay power plant nuclear unit will be California's first full-scale atomic electric generating plant when its General Electric-designed reactor goes into operation in the summer of 1962. Ground breaking for the $20.6 million plant, located near Eureka, California, started in mid-November, 1960. Major construction got under way on January 23rd, 1961, and will be completed in the spring of 1962. The plant will be P. G. & E.'s third generating unit at Eureka. Two gas-oil-fired units now in operation have a capacity of 100-MW. Betchel Corporation, San Francisco, is engineer and prime contractor for the plant, with General Electric furnishing the nuclear steam-supply system, turbine-generator, and other related electrical equipment. The Humboldt Bay power plant nuclear unit will feature an advanced-design single-cycle boiling-water reactor rated at 165-MW of heat, with an initial net electrical output of 50-MW. APED will fabricate and supply 17.3 tons of uranium dioxide nuclear fuel to P. G. & E. under a separate contract. The fuel will be fabricated into 8,428 stainless-steel clad rods and assembled into 172 fuel bundles. The Humboldt Bay atomic plant, in addition to its simplified natural-circulation reactor system, will incorporate two technic-



Mitchells 'packaged' coil boiler under test

Power in a Package

Mitchell's new 'packaged' boiler supplies 10 tons of high-pressure steam an hour for Shell oil wells in Venezuela

The requirements of Compania Shell de Venezuela for high pressure steam at their Venezuelan oilfields dictated a boiler of a special type—a high pressure, forced circulation coil boiler with a capacity of 10 tons an hour. Mitchells designed and built a boiler to meet all these requirements and, in fact, it is now in full operation. Moreover, it is a true "packaged" boiler, i.e. one that can be shipped as a whole. Mitchells have thus paved the way for a whole new family of powerful, compact and transportable boilers.

Mitchells are also active in the fields of boiler design, cableways and ropeways, wagon handling, transporters and conveyors, cranes, mills, ship loading plant and nuclear power.

MITCHELL

MITCHELL ENGINEERING LIMITED
ONE BEDFORD SQUARE · LONDON

ally advanced features—pressure-suppression reactor containment, and internal steam separation, which contribute to compactness of plant design, and reduced capital and maintenance expenses. (*Combustion*, Vol. 32, No. 9, March, 1961, p.32.)

Australia's fuel position

Australia is likely to rely for many years on coal and oil as fuel for electricity generating purposes. Nuclear power will not be economic as compared with conventional coal burning stations until 1975, at the earliest, according to a recent statement by Mr. F. F. Sykes, vice-chairman of the N.S.W. Electricity Commission. Mr. Sykes was commenting on a forecast made by Mr. A. D. McKnight, formerly executive commissioner of the Australian Atomic Energy Commission, and now chairman of the Board of Governors of the International Atomic Energy Agency, that within 30 years, atomic energy would be competing with coal and oil in the field of electricity generation. Mr. Sykes was prepared to concede that in South Australia, nuclear plants might become economic after 1970; but he considered that in N.S.W., where costs are lower than in other states because of the larger generating units, plus the fact that the stations are situated in close proximity to coal-fields, nuclear plants would not be installed for some time beyond 1975. The Prime Minister, Mr. R. B. Menzies, has stressed the importance of raising the level of Australian exports, so far as the coal industry is concerned. This cannot be done without the provision of better coal-loading facilities at the ports. The Australian Coal Commission's chairman, Sir Edward Warren, pointed out that 1,550,000 tons of coal exported during 1960, was worth about £A6 million in foreign exchange, but that this figure could be doubled in two or three years if export terminals were reconstructed to world standards. New ship-loader plants capable of carrying 3,000 tons per hour of coal were needed at Newcastle, Sydney and Port Kembla, and until they were built, the coal industry would be severely limited in the tonnage it could export. Mr. J. M. Simpson, N.S.W. Minister for Mines, announced at the end of January that a five-year, million-ton contract had been secured by Clinton's Naltai Collieries, for the supply of coking-coal to the Fuji Iron and Steel Company of Japan. The coal would be loaded by new equipment at Balmain (Sydney), at a rate of 1,000 tons per hour. Sydney's Maritime Services Board was improving berthing and loading facilities at Balmain, and was considering a scheme for a £A3 million coal-loader, capable of accommodating 40,000 tons colliers (now being commissioned by Japan), at 2,000 tons per hour from two conveyor heads. Appeals have recently been made to Mr. Menzies to prevent unfair competition to the coal industry caused by low-priced residual oil, while the Joint Coal Board, and the colliery proprietors, had asked the Tariff Board to recommend immediate elimination of the protection now given by the Government to the local refining industry. In a further statement early in March, Sir Edward Warren warned that the "dumping" of residual oil could result in the closing of more collieries in the South Maitland coalfield. Sir Edward added that according to the Joint Coal Board, fuel-oil was now being offered at £A7/2/6 per ton which, with other concessions, meant an effective price of less than half the list price. The latest Government move to assist the competitive position of the coal industry was announced on March 15th by Mr. W. McMahon, Minister for Labour and National Service. He said that the Government would submit to Parliament a proposal to exempt all coal exports from the current excise duty of 5d. per ton, and to reduce the excise on home-consumed coal from 5d. to 4d. per ton. The Government's Coal Utilisation Research Advisory Committee continues its efforts to co-ordinate research which is likely to lead to increased demand for coal. Its first report, recently issued, surveys the research and development work on coal now in progress in Australia and summarises its objectives and status.

Lower ash-hopper maintenance

Burning some 1,000 tons of pulverised coal every 24 hours, the 185-MW steam generator at Long Island Lighting Company's Barrett station deposits a ton of ash every hour into a hopper beneath the boiler. The hopper, about 40 ft. long and 20 ft. wide, is partially filled with water drawn from the nearby Atlantic Ocean to quench hot slag and ash before it sluices to the disposal area. Because the boiler furnace and ash hopper are under negative pressure, a water seal surrounds the hopper. To protect the seal from fouling with ash and becoming ineffective, a vertical baffle called a "drip lip" is suspended from brackets welded to the waterwall tubes, and extends around the ash-hopper perimeter. When originally installed, the "drip lip" consisted of ¼-in. thick cast-iron plates coated with 1-in. refractory over wire lathe, but as time went by these began to present problems. Thermal shock was one cause; thermocouples showed that "drip lip" surface temperatures ranged from 500 to 700 deg. F. As slag and ash fell into the hopper, cold sea water, splashing against the hot refractory, caused severe spalling. Cast-iron backing plates, unprotected after the refractory had fallen away, would crack under the repeated heating and quenching cycle. Hot salt water and vapour took their constant toll of corrosion. Service life of the combination proved to be only about six months and repair and replacement became expensive in terms of outage time and man-hours—about 400 for complete replacement. Investigation into the problems resulted in a choice of nickel-iron-chromium plate as a substitute. A few sections installed experimentally quickly proved themselves, so the material was used to complete the "drip lip." Costing less to install, both from labour and material standpoints, the baffle has been in place for the past two years and, to date, has resisted oxidation, hot clinker impact, and, of course, repeated thermal shock. (*Power*, Vol. 105, No. 4, April, 1961, p. 193.)

Mobile Power for Russia

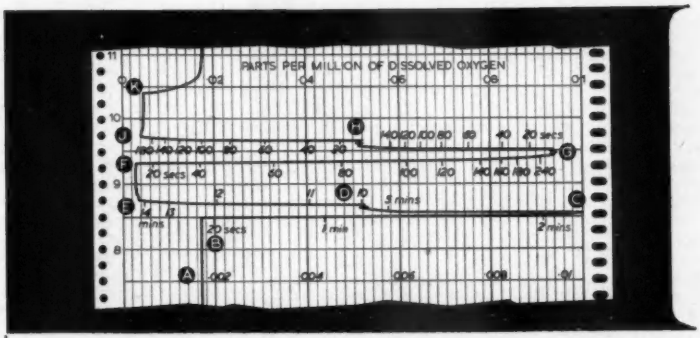
Wartime collaboration with the U.S.S.R., when the Russians were faced with the immense task of reconstruction, will be recalled by the exhibition at the forthcoming Moscow Trade Fair (May 19th-June 4th) of a model mobile power station. Thirty-five of these, made by the Metropolitan-Vickers Works of Associated Electrical Industries Limited, were sent by the Ministry of Supply under the Aid Scheme. They had a total output of 101-MW. The model to be shown in Moscow is of a 5,000-kW set with oil-fired boiler, but those which were sent, included also coal and oil-fired 1,000-kW units and coal-fired 2,500-kW units. These mobile power stations were designed in the early days of the war when it seemed likely that there would be considerable damage to this country's power installations and they were prepared to be mounted on road wagons and on barges. Although Britain fortunately escaped the need for their use, the thought given to the subject was not wasted. Devastation over large and important areas of Russia resulted in a desperate need for power to be immediately available for assisting reconstruction in territories as they became liberated. Here, they had to be mounted on railway rolling stock, and the designs were altered to meet that requirement, bearing in mind the track gauge and the generous loading gauges of the Russian systems. It was stipulated that they should be completely self-contained, requiring only supplies

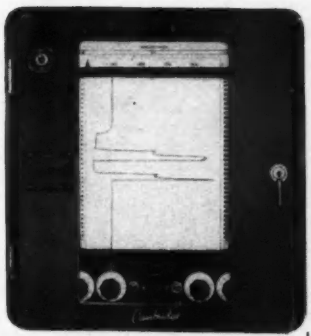
THE FACTS

about E.C.D.O. analysis

(ELECTRO-CHEMICAL DISSOLVED OXYGEN)

- **Accurate and continuous measurement of microgram quantities of dissolved oxygen *is vital* in the boiler feed water of modern high-pressure steam-raising plants.**
- **The Cambridge Mark IV E.C.D.O. Analyser fulfils this function with a system so sensitive that it gives completely specific analyses of dissolved oxygen down to 1 gram in 2,000 million grams of water.**
- **The performance of the Cambridge E.C.D.O. analyser may be judged by the table below.**





Reproduction of a dissolved oxygen record from a Cambridge E.C.D.O. Recorder.

Key. **A** "Steady" at 0.002 parts per million on the low range high-sensitivity scale (0 to 0.01 ppm). **B** 20 seconds after the simulation of a "fault" corresponding to about 0.05 ppm oxygen, the pen is well on its way across the chart. **C** After 2 minutes, the pen is off scale. The recorder is then switched to the high range scale (0 to 0.1 ppm) and the pen returns to a steady value of 0.05 ppm. **D** Ten minutes from the start, the "fault" is cleared and the reading falls rapidly to the usual level (0.002 ppm) though recorded on the less sensitive range (**E**). **F** Sccond "fault" (about 0.10 ppm oxygen) is simulated. **G** The peak value to be reached is held for ten minutes and the "fault" is reduced to 0.05 ppm (**H**). After a further ten minutes, the fault is cleared, and the reading falls to approximately 0.002 (the original value) (**J**). **K** Recorder is switched to original range and pen moves upscale accordingly.

RANGES. Six ranges in each instrument from 0 to 0.01 ppm by wt. (or cc/litre) to 0 to 0.40 ppm by wt. (or cc/litre)

ACCURACY. Better than 0.0005 ppm by wt. (0.5 µg/litre) on ranges 0 to 0.01 ppm or 0 to 0.02 ppm.

SENSITIVITY. Within 0.0001 ppm by wt. (0.1 µg/litre) on ranges 0 to 0.01 ppm or 0 to 0.02 ppm.

RESPONSE. Dead Time: (i.e., *time that elapses before O_2 changes begin to register*), less than 10 seconds.

Half Time: (i.e. *the time within which half the final value is registered*), 50-55 seconds on ranges 0 to 0.10, 0 to 0 20 and 0 to 0.40 ppm, 5 minutes on ranges 0 to 0.01, 0 to 0.02 and 0 to 0.04 ppm.

Equilibration Time: (i.e. *the time in which the final value of any change is registered*), 3-4 minutes on ranges 0 to 0.10, 0 to 0.20 and 0 to 0.40 ppm, 25-30 minutes on ranges 0 to 0.01, 0 to 0.02 and 0 to 0.04 ppm.

- Specific to oxygen—unaffected by impurities or chemical additives.
- Virtually independent of temperature or pressure.
- No filter or ion exchange columns.
- No chemical dosing of sample water.
- Simple maintenance requirements.

Write for NEW List 323 K. For further publications, ask for Mailing Form K/5/61.

Cambridge

ELECTRO-CHEMICAL DISSOLVED OXYGEN RECORDER MARK IV (QUICK RESPONSE TYPE)

CAMBRIDGE INSTRUMENT COMPANY LIMITED, 13 GROSVENOR PLACE, LONDON, S.W.1

of fuel and water on the sites to which they were sent. In transit, the power trains were hauled slowly by locomotives, and at the site were shunted to positions near water supplies. Here, the steam and electrical couplings between tracks were completed and the dispositions for putting into commission could be speedily carried out. Despite the dimensional limitations, they operated with an efficiency comparable with that of permanent land stations of equal capacity. The coal-fired units were also designed to use fuel which varied in calorific value. A number of these units were still in manufacture when the war ended, and they were sent to Egypt, Spain, Iran and China. In Spain they provide the portable power which is required by machines which are used in the wine-producing industry.

Associated Electrical Industries Limited is to supply the largest thermal generating units yet ordered by South Africa. The Electricity Supply Commission of that country is ordering two 125-MW turbine generator sets, together with condensers and feed-heating equipment for installation at the Commission's Komati Power Station in the Transvaal. This important contract (due to be completed in 1964) has been secured in the face of competition, which has been particularly fierce, from continental manufacturers (German firms received the largest orders to be placed for machines for this station). Arrangements are being made for the condensing and heat-exchanger plant for these machines to be made locally to A.E.I. design. A.E.I. has already installed two 100-MVA auto-transformers at Komati Power Station.

* * *

Simon-Carves Limited have received through their Canadian subsidiary, **Simon-Carves of Canada Limited,** a contract to supply a coal-preparation plant for the Crow's Nest Pass Coal Company, British Columbia. The plant will be capable of cleaning 120 tons/hr. of minus half-inch coal. It will be ready for commissioning in April, 1962. Participating in the contract (worth nearly £250,000) will be a Simon-Carves subsidiary—The Automatic Coal Cleaning Co. Ltd., of Carlisle—who will supply the feldspar jig washbox.

* * *

Mitchell Engineering Limited, through their associates, **Mitchell Engineering Prioprietary Limited,** of Johannesburg, have been awarded a contract worth approximately £2¼ million by the Electricity Supply Commission of South Africa for the supply and erection of two boilers for Komati Power Station in the Eastern Transvaal. These boiler units will be the largest installed in the Union, and are due to be commissioned in 1964. Arrangements are being made for some 80 per cent. of the plant to be manufactured in South Africa. Mitchells have already installed two 100-MW boilers at this station.

* * *

Prior Stokers Limited recently issued a leaflet concerning the range of self-contained gas-burners, which they have just introduced. These automatic forced draught packaged gas-burner units are compact, robustly built burners for the efficient combustion of town gas with a calorific value of 500 B.Th.U./cu. ft. at a pressure not exceeding 2 in. w.g. The units have been designed to incorporate all component parts in one assembly, which can be fitted quickly and easily, in the shortest time and they occupy the minimum amount of space. The burner controls ensure that operation is to rigid standards of safety.

The Engineering Group of the **General Electric Co. Ltd.** has recently revised their Technical Description No. 277, which deals with high-torque, high-slip and high-reactance squirrel-cage motors. High-torque motors are substantially the same as standard squirrel-cage motors with the exception that the rotor has two separate squirrel-cage windings. One of these windings has a high resistance and low reactance, while the other has a low resistance and high reactance. The combination of the output torques of these two windings produces a comparatively high torque from standstill to full speed. By adjustment of the values of the resistances of the two windings, different speed-torque characteristics can be obtained giving motors eminently suitable for, say, lift operation or the textile industry. High-slip motors are employed where the load varies very rapidly, sometimes to the extent of consisting of a series of sharp peaks with periods of light load, examples being shears, presses and hammers. Usually, such machines have a flywheel embodied in their construction and to reduce the power drawn from the supply it is necessary to arrange for the drive motor to run with something like 10 per cent. slip at full load. This necessitates a special design of rotor winding capable of dissipating the increased power generated in it. G.E.C. has available a range of high slip motors for the types of drives mentioned above with outputs as high as 200 h.p. High reactance motors are available from G.E.C. for direct-on-line starting. This type of motor is especially suitable for drives in which inertia is high, such as a fan having a heavy impeller, and for pumps starting up on load. The speed-torque curves of such a motor follow the same pattern as the required driving torque with sufficient excess to allow for smooth acceleration. A table included in the revised publication T.D. No. 277 shows the diversity of drives for which G.E.C. high-reactance motors have been supplied ranging from boiler feed pumps to high-frequency alternators. This table also indicates the range of horsepowers, speeds and voltages of these motors.

* * *

Darchem Engineering Limited, a member of the Darlington Chemicals Group, announces three new appointments. **Mr. A. B. Miles,** previously chief draughtsman, becomes chief engineer. **Mr. F. Meadows,** formerly assistant chief draughtsman, succeeds Mr. Miles as chief draughtsman. **Mr. D. A. Rowlett,** M.Sc.(Eng.) London, has been appointed manager of the Rostenit (stainless-steel lining process) Division. A metallurgist, he joined the company in 1960 from the Standard Telephones and Cables Company, where he was assistant chief metallurgist. Darchem Engineering Limited are high-temperature insulation specialists and precision fabricators of metals. Experience gained in the field of specialised welding techniques on light-gauge steel in the aircraft industry is now being applied to other metals in industry.

* * *

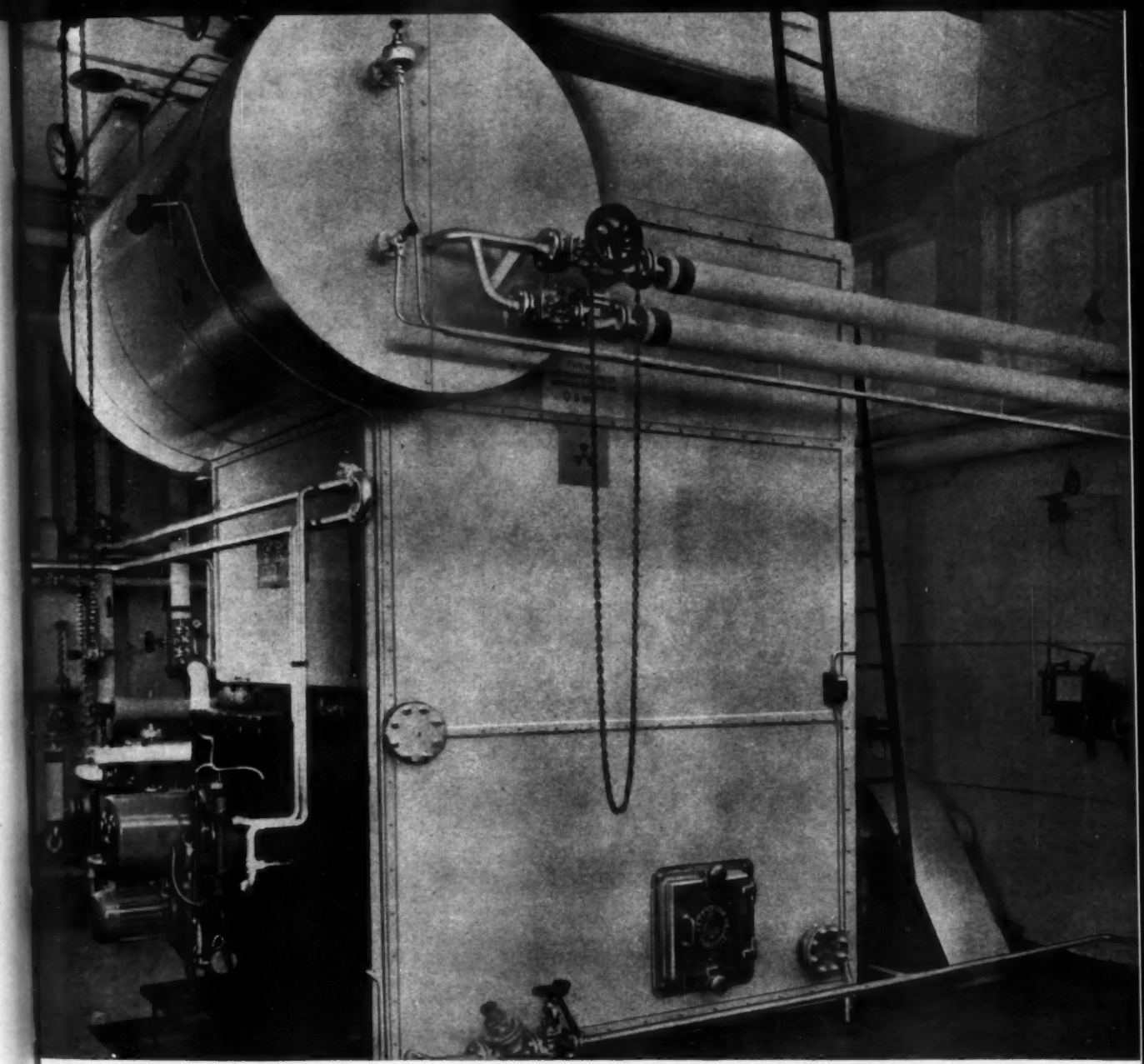
An arrangement has been made between **Head Wrightson Processes Limited** and the "Alfloc" Water Treatment Service of **Imperial Chemical Industries Limited,** whereby the two concerns will collaborate in the assessment and solution of problems relating to treatment of trade and other wastes before discharge to sewers or water-courses. In addition, a special study will be made of the re-use of water within industry, with the view to alleviating problems of water supply and of disposal of wastes. For many years "Alfloc" Water Treatment Service has specialised in the treatment of water of all types, including that grossly polluted, for the needs of industry, and much of the information and experience they have acquired will be of particular value in dealing with effluent problems. Likewise, Head Wrightson Processes Limited, aided by their associated companies within the Head Wrightson Group, have long experience in the construction of special plant and have recently extended their activities into the water treatment field. Whenever possible, the approach to the solution of problems will follow chemical engineering practice to facilitate the incorporation of standard plant of proved performance and to avoid expensive civil engineering works.

* * *

W. H. Allen Sons & Co. Ltd., Bedford, have received an order from Thames Board Mills Limited, Purfleet, Essex, for the supply of one 10.5-MW pass-out back-pressure turbo-alternator set. The machine will be designed to operate with steam at 600 lb./sq. in. and 740 deg. F., passing out up to 120,000 lb./hr. of process steam at 55 lb./sq. in. with an equal quantity available at an exhaust pressure of 21 lb./sq. in. under conditions of reduced pass-out flow. The Allen turbine will run at 3,000 r.p.m. and drive directly, an English Electric water-cooled alternator supplying power in parallel with existing machinery for an 11-kV, 50 c/s supply at 0.8 p.f. The plant is to supply power and process steam for the expansion programme of Thames Board Mills Limited, who, in the first phase, are installing a new packaging board machine which will initially produce 80,000 tons per year.

* * *

Hayward, Tyler & Co. Ltd. have been awarded a contract from **Babcock & Wilcox Limited** for the supply of 16 l.p. and 16 h.p. glandless motor pump units for water circulation at Sizewell Nuclear Power Station. Value of the contract is said to be about £100,000.



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- Robust. The boiler tubes, down-comers, etc. form a strong, welded, cage-like structure
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FULL DETAILS OBTAINABLE FROM Newton Chambers & Co. Ltd., Engineering Division, Thorncliffe, Sheffield.

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Latest Power Plant Patents

These extracts from British Patent Specifications are reproduced by permission of The Controller of H.M. Stationery Office. (Complete British Specifications can be obtained from the Patent Office, 26, Southampton Buildings, London, W.C.2. Price 3s. 6d. each, both inland and abroad.)

Steam generator with radiant superheater

In superheating steam to the high temperatures required in modern power plants, it becomes desirable or necessary to have recourse to radiant superheaters. These are in service subject to onerous conditions, and an object of this invention is the provision of radiant superheaters of improved construction. The invention includes a radiant superheater platen, having parallel-connected tubes, each comprising limbs extending pendently in upright positions and united at their lower ends by a return bend. The limbs of the different parallel-connected tubes are disposed in a row, in which the return bends are of small radius, and adjacent limbs of neighbouring tubes are rigidly connected together and arranged for flow of steam through them in the same direction. Fig. 1 is a sectional side outline elevation of a steam generating and superheating unit provided with a radiant superheater (89). Referring to Figs. 2, 3, 4 and 5, the radiant primary superheater (89) includes a number of pendent tube platens, spaced across the upper region (3) of the furnace chamber (1), connected in groups to suitable headers. Thus, four similar

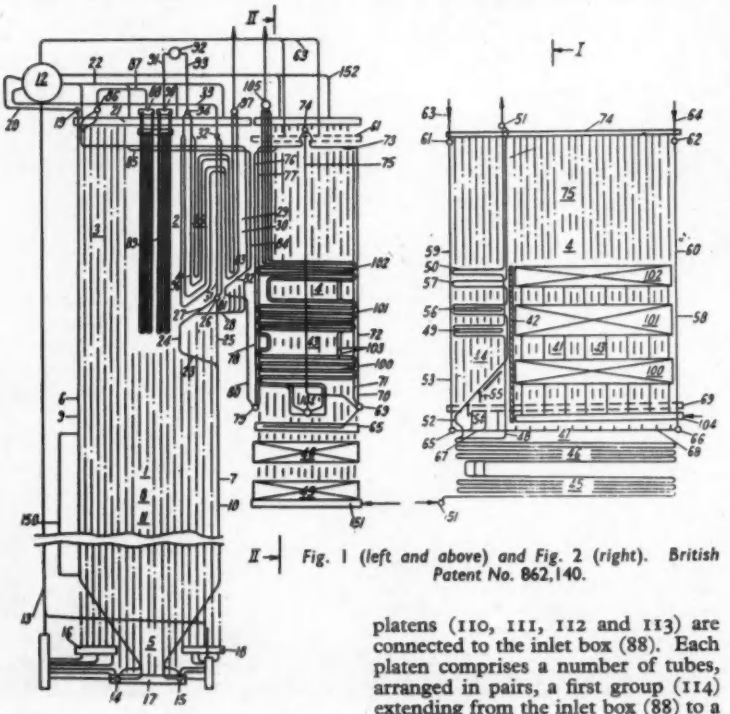
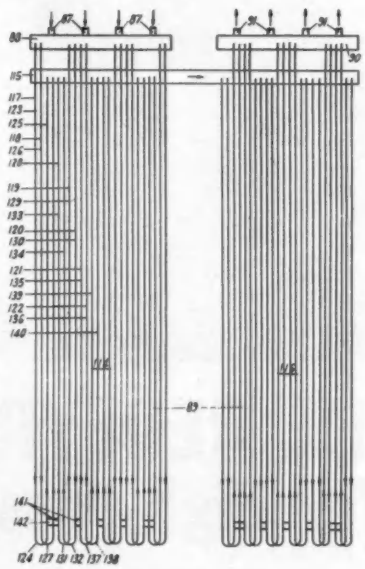


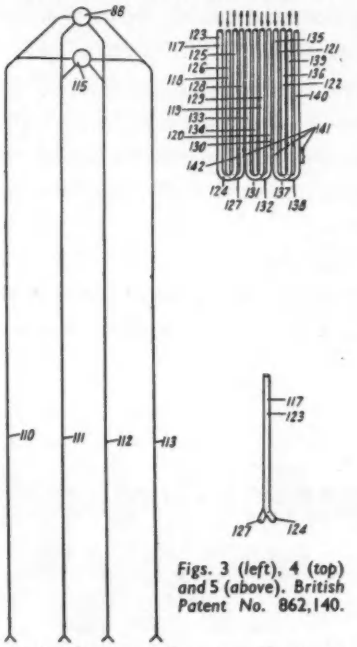
Fig. 1 (*left and above*) and Fig. 2 (*right*). British Patent No. 862,140.

platens (110, 111, 112 and 113) are connected to the inlet box (88). Each platen comprises a number of tubes, arranged in pairs, a first group (114) extending from the inlet box (88) to a transfer header (115), and a second group (116) connecting the transfer header (115) to the outlet-box (90). Thus, the platen group (14) comprises a number of tubes arranged in pairs such as the tubes (117, 118, 119, 120, 121 and 122). The tube (117) has a downflow limb (123) connected into the inlet box (88), a return bend (124), of small radius, angled out to the right as seen in Fig. 5, and an upflow limb (125) having a centre-line spaced approximately three tube diameters from the centre-line of the downflow limb (123) and connected into the transfer header (115). The tube (118) extends with a downflow limb (126) adjacent to the downflow limb (123), a return bend (127) of small radius angled out to the left, as seen in Fig. 5, and an upflow limb (128) having a centre-line spaced approximately three tube diameters from the centre-line of the downflow limb (126) extending adjacent to the upflow limb (125), and connected into the transfer header (115). The tubes (119 and 120) are arranged as a pair in a similar manner, and have respective down flow limbs (129 and 130), return bends (131, 132) of small radius, and upflow limbs (133 and 134). Similarly, the tubes (121 and 122) are arranged as a pair, and have respective downflow limbs (135 and 136), return bends (137 and 138) and upflow limbs (139 and 140). Plates (141) are welded between the adjacent outer limbs (128, 133 and 130, 135) of each pair of tubes, and serve to maintain the tubes in alignment. A further plate (142) is welded between the two upflow limbs



(125 and 128) to anchor the outer tube (117). The remaining tubes of the group (114) are arranged in a similar manner, Since the return bends of the tubes of each platen of the primary superheater are all of small radius and similar to one another,

radiation to the return bends from the furnace space below the platen is approximately the same to each bend and of limited value, as opposed to the nested arrangement in which radiation to each of the bends is different and to the outermost bend

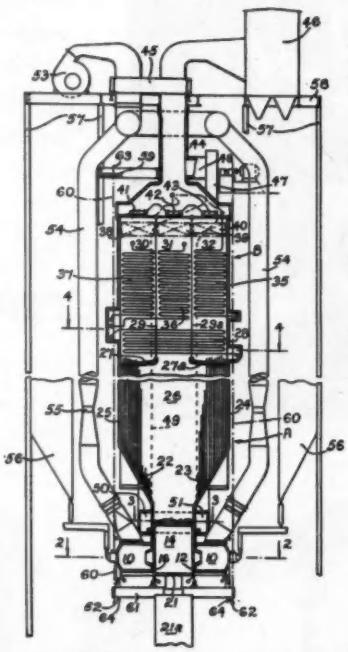


Figs. 3 (left), 4 (top) and 5 (above). British Patent No. 862,140.

relatively large. The return bends are effectively cooled by rapid heat transfer to the adjacent portions of the tube limbs, and a more even heating of the tubes is obtained than if the tubes were in nested formation. Due to the more even heating, the task of boiling out the tubes on starting up, the unit is simplified. Since the adjacent limbs of neighbouring tubes are united by plates welded to the limbs, the platen groups are rigidified and the tube limbs are maintained in alignment and furthermore, since the limbs are approximately evenly heated and the temperatures of the steam entering the limbs are approximately the same, objectionably high stresses due to differential thermal expansion of the pairs of limbs united with one another are avoided. *British Patent No.* 862,140 *issued to Babcock & Wilcox Limited. Complete specification published March* 1st, 1961.

Forced-flow once-through steam generator

A partial sectional elevation of a forced-flow once-through steam generator for operation at supercritical pressure is shown in Fig. 6, while Fig. 7 is a diagrammatic representation of the water and steam flow path within the steam generator (Fig. 6). The outline arrangement illustrates a forced-flow once-through steam generating and superheating unit intended for central power station use, and designed for a maximum continuous steam flow of 2,900,000 lb./hr., at a pressure of 3,625 lb./sq. in. and a total steam temperature of 1,050 deg. F. at the superheater outlet, based on a supply of feedwater at 4,500 lb./sq. in.; and coal firing. The unit includes two steam reheaters, one to raise the temperature of 2,530,000 lb./hr. of steam at 1,300 lb./sq. in. from 787 deg. F. to 1,050 deg. F., and the



second to raise 1,980,000 lb./hr. at 330 lb./sq. in. from 700 deg. F. to 1,050 deg. F. Referring to Fig. 6, a vertically extending setting of rectangular cross-section provides a furnace chamber (A) and a superjacent convection gas-cooling chamber (B). The setting is completely-lined with fluid heating tubes from the lowermost walls of chamber (B). The unit includes eight cyclone furnaces (10) which are independently fired by crushed or granulated coal. Four of the cyclone furnaces are arranged separately to discharge combustion products and molten slag through the wall (12) into a small volume lower portion (14) of the furnace chamber (A) and the other four cyclone furnaces are arranged separately to discharge combustion products and molten slag into the lower portion (14) of the furnace chamber (A) through the opposite wall (16). End walls (18 and 20) bound the setting from top to bottom, each in a single vertical plane. Thus, the walls (12, 16, 18 and 20) form the lower furnace chamber portion (14) having slag-discharge openings (21) in its base to discharge molten slag received from the cyclone furnaces (10) into a slag tank (21a). The walls (12, 16, 18 and 20) of the lower portion (14) of the furnace chamber include a number of small-diameter fluid-heating tubes covered by refractory to reduce the heat input into the tubes and to maintain the temperature in the cyclone furnaces and in the lower furnace chamber portion (14) above the ash fusion temperature, and to provide conditions conducive to the collection of molten slag. At the top of the lower furnace chamber portion (14) the opposite parallel walls (12 and 16) diverge upwards, and both uniformly and symmetrically to present sloping walls (22 and 23) and thence rise vertically as walls (24 and 25). The sloping walls (22 and 23) and the vertical walls (24 and 25) in conjunction with the end-walls (18 and 20) enclose an upper furnace portion (26) and the convection gas-cooling chamber (B). The convection gas-cooling chamber is separated from the upper furnace portion (26) by the tube screens (27 and 27a) which are formed by certain tubes taken from the walls (24 and 25). These tubes rise vertically upwards in spaced relationship to support a secondary superheater (28) which spans the entire setting width in the lower portion of the chamber (B). Above the superheater (28) the vertical tubes form fluidtight baffles (29 and 29a) to define three parallel gas-passes (30, 31 and 32). A primary superheater (35) of the unit is arranged in the pass (32) while a first-

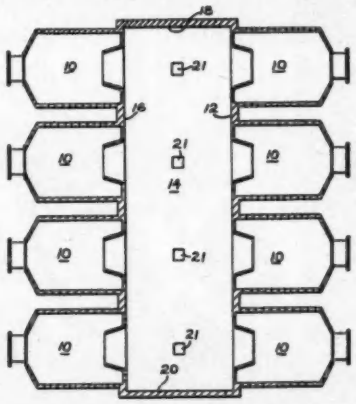


Fig. 6. British Patent No. 862,183.

COLMAN'S are keen as mustard-on COAL

Homo sapiens has seldom been content to take food as he finds it—and it is this desire to titillate the appetite which has created a gastronomic world that is one of the highlights of every civilization. In this world of rich odour and delicate flavour Colman's mustard is an essential servant, waiting upon both taste and digestion with unfailing diligence.

The men who control and direct this great company—with over a score of products that are favourites with the British housewife—chose coal

PROGRESSIVE INDUSTRY IS GOING FORWARD ON

ISSUED BY THE NATIONAL COAL BOARD

to fire the boilerhouses of their vast factory at Norwich. They choose coal because coal provides them with the greatest heat for the lowest cost; because coal, mechanically stoked, is smokeless, and because our coalfields contain enough coal to supply all the fuel needs of British industry for generations to come.

When you have to make a decision about fuel, be wise—like Colman's—and choose coal. It could well help to make your product a hot favourite for top place.

COAL

Coal Supplies the Power at Colman's Carrow Factory.
Mr. P. S. O. Durrant, Works Engineer comments:

"Coal-fired boilers can be expected to maintain a high efficiency throughout their life. That is one of the reasons why we use coal to supply the power at Colman's.

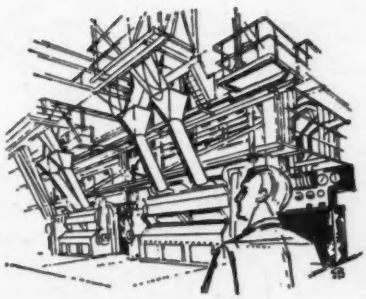
We had proof of our decision when we called in a fuel efficiency team to investigate the state of our boilers after 26 years' service. They were able to report that the overall efficiency was 'extremely good'. In fact, they found an overall thermal efficiency of 81.7%.

Our present installation dates back to 1926 when a central boiler house equipped with four coal-fired water tube boilers replaced a number of small units scattered throughout our works. In 1930 a fifth boiler was added to cope with increased demand, and these five have satisfied our steam requirements ever since.

The boilers which are conservatively rated at 8,000 lbs. per hour each operate at a steam pressure of 250 lbs. per sq. inch with a temperature of 600°F. The coal, burned on chain grate stokers, arrives on site mainly by rail whence it is elevated to a U-link conveyor feeding the bunkers. We sell the ash to a local contracting firm.

Steam is used both for process and space heating, and a recently installed back-pressure turbo-alternator generates a proportion of our power requirements.

We look back over more than thirty years' experience of burning coal on chain grate stokers with the conviction that no other fuel can meet our needs economically."



Here are some key facts and figures about the consumption of coal at Colman's:

Number of boilers: .....5 water tube
Method of firing: .....Chain grate stokers
Steam pressure: .....250 lbs. per sq. inch
Continuous max. rating: .8,000 lbs. per hour each
Steam temperature: .....600°F.
Feed temperature: .....138°F.
Annual fuel consumption: .....6,000 tons of coal

stage reheater (36) is arranged in the central pass (31) and a second-stage reheater (37) is arranged in the pass (30). Above the superheater and reheaters, and in each of the gas passes (30, 31, 32) is disposed an economiser which is divided into three sections (38, 39 and 40) one in each pass. Gas dampers (41, 42 and 43) individually control the gas-flow rates in the respective gas passes (30, 31 and 32). At the top of the unit is a gas breeching (44) arranged to direct the gas in an upward direction through an air-heater (45) and thence through a precipitator

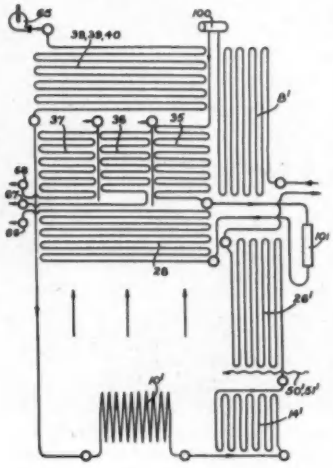


Fig. 7. British Patent No. 862,183.

(46) to a chimney (not shown). A gas-recirculating fan (47) is arranged to remove a portion of the gas from the breeching (44) through a duct (48) and to discharge the gases into supply ducts which are on the opposite end walls (18 and 20) of the setting. The gases pass downwards through the ducts and into distributing chambers which run the full width of the setting above the cyclone furnaces (10). A number of gas openings or nozzles, preferably provided with dampers, formed in the opposite parallel walls (12 and 16) are uniformly distributed across the entire width of the walls to provide for the mixing or recirculated gas with the combustion products from the lower portion (14) of the furnace chamber, and thereby control the gas temperature entering the convection gas-cooling chamber (B) to a value below the ash fusion temperature. The gas recirculation rate in the unit at maximum continuous rating is approximately 40 per cent. of the gases generated by the combustion of the fuel. In addition to controlling the slagging temperature of the combustion gases, the recirculated gas effects a lower heat input rate to the furnace walls (17, 20, 24 and 25) of the upper portion (26) of the furnace chamber (A). Combustion air for the cylone furnaces is supplied by the forced-draught fan (53) through the air-heater (45) and individual supply ducts (54) which are symmetrically arranged transversely to the setting, and supply the respective cyclone furnaces. Within each supply duct (54) is a venturi section (55) arranged to meter the air for the control of combustion. Adjacent to the air-ducts are shown portions of the coal hoppers (56) which are arranged to supply crushed coal to the cyclone furnaces (10). *British Patent No. 862,183 issued to Babcock and Wilcox Limited. Complete specification published March 1st, 1961.*

Marine boiler and turbine installation with separately fired reheater

This invention relates to marine propulsion steam turbine installations of the type in which superheated steam for a boiler assembly is supplied to a turbine assembly comprising at least two pressure-stages and having provision for interstage reheating of the steam in its flow from stage to stage. In the example shown in outline in Fig. 8, the installation includes a main water-tube boiler including the customary water-drum (10), steam-drum (11) and oil-fuel burners (12) and comprising the following stages through which the gaseous products of combustion flow in their passage from the burners to the ship's funnel, namely:—the combustion chamber (13), the zone (14) occupied by the boiler tubes (15) extending between

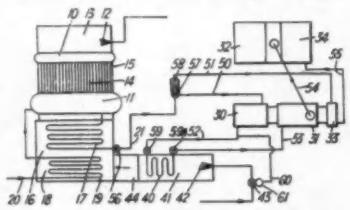


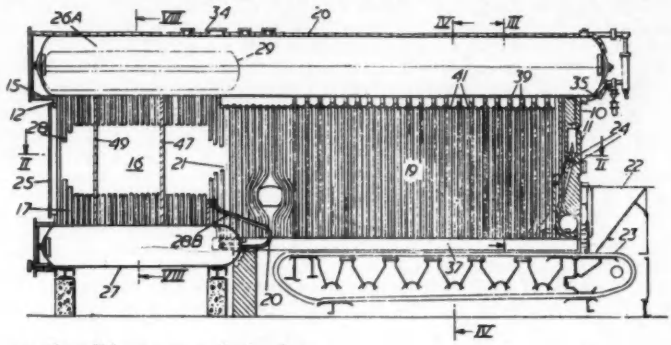
Fig. 8. British Patent No. 862,563.

the drums (10 and 11), the superheating zone (16) occupied by the superheater tubes (17), the economiser (18) with its tubes (19). As is customary, feedwater is supplied through piping (20) to the economiser tubes (19) and passes to the boiler proper, namely, the drums (10 and 11) and tubes (15), from which steam is supplied through the superheater tubes (17) to the main steam piping (21). Both the economiser and the superheater are tubular heat-exchangers. The installation also includes an interstage reheater, which is also a tubular type heat-exchanger, its tubes being indicated by (40). This heat-exchanger has a combustion chamber (41) fitted with one or more burners (42) to which oil fuel is supplied under the control of an automatic control valve (43). The combustion chamber has an exhaust passage (44) in the form of ducting which, in the example, connects the reheater with the economiser (18) in such a manner that the gaseous products of combustion will pass into the boiler structure and act upon the economiser tubes (19) and will mingle with the gaseous products from the boiler itself and pass with them from the structure. Valves (59 and 59A) are provided in order that the reheater can be isolated for inspection, servicing and repair. The automatic control valve (43) for the fuel oil supply to the reheater has a mechanical connection with a pressure-operated device (61) connected by a pipe (60) with the piping (52) from the high-pressure stage of the turbine to the reheater. The arrangement is such that if the pressure falls below a predetermined limit, the valve (43) automatically closes and shuts off the supply of fuel, but so long as the pressure remains above this limit, the device (61) is ineffective to vary the fuel supply. *British Patent No. 862,563 issued to The Fairfield Shipbuilding and Engineering Co. Ltd. Complete specification published March 15th, 1961.*

Compact steam generator unit

This invention relates to steam generating units and in particular to units of such dimensions that the units may be shop assembled, tested and transported to a desired location in the assembled form. Referring to Figs. 9 and 10, the steam generator includes a setting (10) with rectangularly-disposed front, rear and opposed side walls (11, 12, 13 and 14) and a top wall or roof (15) defining a convection section (16) having a pair of side-by-side convection heat-absorbing units (17, 18) and a forwardly positioned furnace or combustion chamber (19) common to each of the tube bank units (17 and 18). At the junction of the furnace section (19) and the convection section (16) is a refractory bridge wall (20) which extends upwards a short distance, and which in conjunction with the side walls (13 and 14) and roof (15) defines an opening or gas-flow area (21) by which the furnace section (19) is in open communication with the convection section (16). In this form of the invention, the

furnace section is arranged for burning a solid fuel, as, for example, coal or such like, which is fed from a suitable hopper (22) on to a travelling-grate stoker (23). Overfire air is supplied through a number of jet nozzles (23) positioned in the front-wall (11) of the furnace, the nozzles (24) directing the air so as adequately to mix the combustible gases and air above the moving fuel-bed of the travelling-grate stoker (23). The heating gases thus generated in the furnace rise and flow over the bridge wall (20), through the flow area (21) into the convection section (16), the gases being directed through the convection section (16) in sinuous flow paths. A flue opening (25) in the rear-wall provides means whereby the cooled gases may leave the convection section (16). In operation, the heated gases generated within the furnace-section (19) radiate heat to the furnace-wall cooling-tubes (14, 42 and 45) to produce steam. The gases from the furnace section (19) enter the convection section (16), flowing in convection heat transfer relationship across the banks (28 and 31) of the convection heat-absorbing units (17 and 18). Baffles are provided within the convection section (16) for deflecting the gases in horizontally sinuous flow-paths. Thus, laterally aligned baffles (46 and 47) extend inwardly from the opposite side walls to provide a central restricted opening or flow area (48) through which the gases, after entering section (16), are directed. Positioned downstream gas flow-wise, and in line with the restricted opening (48) is a second baffle member (49) which has its ends (49A, 49B) spaced from the side walls (13 and 14). The baffle (49) functions as a deflector causing, the gas-flow to diverge outwardly around the ends through flow areas (50 and 51) defined by the outer ends (49A and 49B) of the baffle (49) and the adjacent side-walls (13 and 14). To ensure that the gases flow in substantially horizontal strata throughout the convection section (16) and hence in substantially wholly cross-flow heat transfer relationship with respect to the tube banks (17 and 18), the baffles (46, 47 and 49) extend vertically substantially throughout the entire height of the convection section. With this arrangement, optimum heat transfer is attained with a minimum draft loss through the convection section (16). The heating gases entering the convection section (16) their temperature decreasing as they flow through it. Thus, the tubes in banks (28 and 31) adjacent the furnace section (19) are heated by the high-temperature gases, thereby causing the generation of steam in them and inducing an upward circulation. The tubes at the rear of the convection section (16) are acted upon by the cooler gases, and are thus heated to a lesser extent whereby a downward circulation is induced in them due to the difference in density of the water within the tubes at the rear of the convection section (16) and the tubes adjacent the furnace section (19). With this arrangement adequate circulation is established in each of the circuits so that a high rate of steam generation may be attained in a small space and with good operating efficiency. The arrangement of the tubes of banks (28 and 31) in rows transversely arranged in pairs is advantageous, in that it permits ready access to any of the tubes in the event of their requiring repair or replacement. This is readily accomplished by cutting the tube at the respective drums and taking the cut tube out through the space provided between tube groups. Thus, outage time, expense and labour cost in making tube replacements is reduced to a minimum since only the defective tube need be removed. *British Patent No. 862,993 issued to the Babcock & Wilcox Company. Complete specification published March 15th, 1961.*



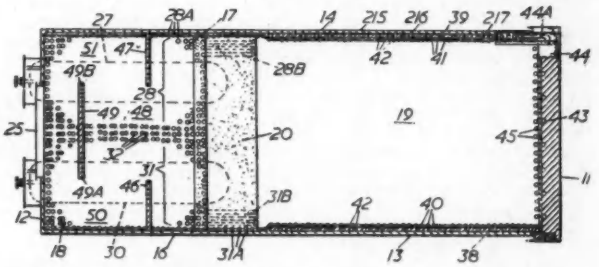


Fig. 9 (above). and 10 (right). British Patent No. 862,993.

A British bottling company, R. P. Brindley & Co. Ltd., Leeds, are to install oil-fired packaged boilers on the roof of their new factory to provide all its process steam needs. The factory will centralise under one roof all the peripheral activities of the subsidiary companies, and will provide added production and warehousing capacity. The principal reasons for siting the Stone-Vapor boilers on the roof are that:—ground floor and basement space are thereby released for production; steam supplies are piped overhead to the plant, thus keeping the floor area clear and allowing a consequential saving in the length of piping and accessibility for supervision by responsible executives with offices on the first floor. The three Stone-Vapor type OK 4625 boilers, will raise steam within 2 min. from cold, to a combined total output of 9,000 lb./hr. This arrangement also permits modulation at high efficiency down to 750 lb./hr.

Elliott-Automation Limited, which already has extensive interests in France and other countries in the European Common Market, including Holland and Germany, has formed a new subsidiary company, **A.B. Elliott-Automation,** in Sweden, one of the countries in the European Free Trade Area. **Mr. J. W. Grant,** manager of the Industrial Weighing Division of Elliott Brothers (London) Limited, a member of the Elliott-Automation Group, recently went to Stockholm to establish the new company and to consolidate the group's existing interests there. He will have the assistance of A.B. Termostatik, the Swedish subsidiary of the Rheostatic Co. Ltd.

* * *

Mr. B. C. Morton, M.I.Mech.E., M.Inst.Gas E., who has been managing director of Robert Dempster & Sons Ltd., engineers, Elland, Yorkshire, since 1942, has also been appointed deputy-chairman of the company.

NOTES *Personal* AND *Industrial*

Mr. Anthony M. Browne, B.Sc., A.R.C.Sc.I., was elected president of the British Electrical and Allied Manufacturers' Association at a recent meeting of the Council of the Association in London. **Mr. H. H. Mullens,** B.Sc., M.I.E.E., was elected deputy president. Mr. Browne is chairman and managing director of Hackbridge and Hewittic Electric Co. Ltd. and chairman of Combined Electrical Manufacturers Limited. He has been a member of the B.E.A.M.A. Council since 1954 and is a member of the B.E.A.M.A. Export Panel and of the recently formed Export Council of Europe. Mr. Mullens is chairman and managing director of A. Reyrolle & Co. Ltd., and chairman of C. A. Parsons & Co. Ltd. He was chairman of the North Eastern Electricity Board, 1948-1954, and a member of the British Electricity Authority 1952-53.

* * *

Sir Ellis Hunter has retired from all executive appointments in the Dorman Long Group, including the joint managing directorship of Dorman Long (Steel) Limited. He continues as chairman of Dorman, Long and Co. Ltd., and its principal subsidiary companies. **Mr. E. T. Judge** has been appointed deputy chairman of Dorman Long and Co. Ltd., and managing director of Dorman Long (Steel) Limited, of which he was previously joint managing director.

* * *

Mr. Kenneth Arthur Oliver has been appointed chief metallurgist of the Brightside Foundry and Engineering Co. Ltd., Sheffield.

* * *

Mr. H. W. G. Hignett and **Mr. Jean M. Dhavernas** have been appointed directors of The International Nickel Co. (Mond) Ltd. Mr. Hignett remains managing director of Henry Wiggin and Co. Ltd. Mr. Dhavernas is located in Paris and has been closely concerned for many years with nickel markets on the Continent.

* * *

During April, **Dr. H. G. Taylor,** director of the Electrical Research Association, paid a visit to New York, Toronto and Montreal. The primary object of his visit was to attend the annual assembly of the International Institute of Welding, held in New York from April 11th to 18th.

* * *

Thos. W. Ward Limited announce the appointment of **Mr. S. Jessop** as manager of their works at 18/24, Fore Street, Scotstoun, Glasgow. He will be in charge of the company's engineering interests in Scotland.

* * *

Mr. D. K. Fraser, joint managing director, G. A. Harvey & Co. (London) Ltd., has been appointed managing director. **Mr. H. E. Cooper** has relinquished his office of joint managing director, but remains a director of the company.

Mr. C. M. Stoupe, B.Sc., M.I.E.E., formerly deputy chief engineer, Electricity Board for Northern Ireland, has been appointed general manager and chief engineer, following the retirement recently of **Mr. T. G. Christie,** Mr. Christie will, for a limited period, be engaged on special duties for the Board. **Mr. J. J. Patterson,** A.C.A., chief accountant and financial controller will, as heretofore, be responsible for the financial arrangements and all accounting matters in connection with the Board's undertaking.

* * *

Mr. W. R. Owen has been appointed to take charge of the Cardiff and Manchester branches of Honeywell Controls Limited, in addition to continuing as Birmingham branch manager. This follows the transfer of **Mr. T. Jackson** and **Mr. R. Robson** from Manchester and Cardiff respectively to head office positions at Greenford.

* * *

Mr. W. Washbourne, who was appointed general manager of the Excavator Division of Newton Chambers and Co. Ltd., Thorncliffe, Sheffield, at the beginning of this year, has now been appointed a director of two Newton Chambers subsidiary companies—NCK-Rapier Limited and Rhodes and Halmshaw Limited.

* * *

Mr. H. L. Satchell, M.B.E., F.I.W.M., director of manufacture, Associated Electrical Industries (Rugby) Limited, retired recently after 41 years' service with the company. In June, 1940, he became assistant manager, and in March, 1945, manager, Rugby Works. Mr. Satchell became a director of the company in 1949, deputy director of manufacture in 1955, and director of manufacture on October 1st, 1957.

* * *

The London Electricity Board announces the appointment as chief engineer to the Board of **Mr. A. G. Milne,** M.I.Mech.E., M.I.E.E. He succeeds **Mr. L. H. Welch,** O.B.E., B.Sc., M.I.E.E., on his retirement. Mr. Milne is at present manager of the Bristol District of the South Western Electricity Board and before his appointment to that post last year had been deputy chief engineer, South Western Board.

* * *

Mr. F. R. Allen, an executive director of Firth Cleveland Instruments Limited, is now in charge of the company's Sales Engineering Department. **Mr. W. J. Megson** has joined the company as instrument representative for the North-East England area.

* * *

An £8,500 contract for dealkalisation-base exchange and deaeration plants has been awarded to **William Boby and Company,** Rickmansworth, Herts., by John and E. Sturge Limited, Birmingham.

Mr. Bernard Wright, until recently sales manager of John Thompson Instrument Co. Ltd., has commenced duties as sales manager of the B.W. Valve Co. Ltd., a wholly-owned subsidiary of Charles Winn & Co. Ltd. He will operate from offices at 35 Maddox Street, London, W.1.

* * *

C. A. Parsons & Co. Ltd. announce that **Mr. E. C. Rippon** has been elected as a director of the company. Mr. Rippon, formerly chief transformer engineer, has during the last year, been engaged in matters relating to the organisation of design and production throughout the works. He has, for a number of years, represented British interests on international technical committees in the field of transformer engineering, and has contributed to standardisation work both at home and abroad. He will continue this interest in such technical matters.

* * *

A new company—**Flexibox N.V.**—has been added to the **Flexibox** organisation, to handle sales of Flexibox mechanical seals in the Benelux countries. The new firm has been formed jointly by **Flexibox Limited** and their present Dutch agents—**Technisch Bureau Vaillant & Sluyterman**—and will operate from Noordeinde 18a, The Hague.

* * *

Dewrance & Co. Ltd. announce the formation of the "Dewrance Metals Division." This will consist of the foundry at Hillington, and the Special Alloys Division in London. The new division will have its own board of management, and will be responsible for the production and sales of high-quality non-ferrous castings, nickel castings, stainless-steel castings, "Endewrance" hardfacing and high-temperature brazing alloys. The production executive is **Mr. J. B. Morton,** who will operate from Hillington, and the sales and technical executive is **Mr. E. Wallace,** who is at the company's head office in London.

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The Council of the Institute of Metals has appointed **Mr. R. E. Moore** to succeed **Lieut.-Colonel S. C. Guillan,** T.D., who retired on April 30th, as secretary of the Institute. Mr. Moore has been assistant secretary of the Institute since 1947. Before joining the Institute of Metals Mr. Moore was assistant to the Registrar of the then recently-formed Institution of Metallurgists.

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Richardsons, Westgarth (Hartlepool) Limited have received an export order approaching £100,000 in value, for the supply of three 14,700 sq. ft. surface, three-pass, steam condensers and associated equipment. The order was received through Brown-Boveri Switzerland.